digester gas systems workshop

Ministry of the Environment
Ontario

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DIGESTER GAS SYSTEM
MAINTENANCE WORKSHOP

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PREFACE

The manual for the Digester Gas System Maintenance Workshop is designed as a home study and reference text for treatment plant operators and maintenance staff. It includes safety procedures which must be followed to ensure compliance with appropriate Ontario regulations and codes.

The five day workshop based on the manual is held at the Ministry Training Centre, Ontario Experimental Facility Brampton Ontario. Successful completion of the program provides the trainee with the knowledge and skills required to maintain a digester gas distribution system. It also prepares him to write the Maintenance Gas Fitter Certification Examination administered by the Ontario Ministry of Consumer and Commercial Relations.

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SUBJECT:

DIGESTER OPERATIONS

TOPIC: 1

ANAEROBIC DIGESTION

OBJECTIVES:

The trainee will be able to:

1. Recall the objectives of sludge digestion.
2. Understand the Anaerobic Digestion Process
3. Show by a simple diagram the Anaerobic Digestion Process
4. Recall the characteristics and composition of a typical digester gas
5. Name the methods used
   a. to heat a digester
   b. for digester mixing

ANAEROBIC
DIGESTION OF SLUDGE

OBJECTIVES OF SLUDGE DIGESTION

Settled solids and floating scum removed from the sedimentation tanks and clarifiers consist of a watery, malodorous mixture called raw sludge. In the majority of the plants this raw sludge is pumped to a digester for treatment before disposal. The primary purpose of sludge digestion is to reduce the complex organic matter present in the raw sludge to a material that:

1. is relatively odour free
2. can be readily dewatered
3. is capable of being disposed of without causing environmental problems
4. will undergo little or no further decomposition

Digestion of sludge can be carried out either by anaerobic or aerobic processes. This topic deals with the anaerobic digestion only, since one of the by-products of this process is digester gas.

ANAEROBIC DIGESTION PROCESS PRINCIPLES AND THEORY

GENERAL

The anaerobic digestion process can be carried out as a single or double stage operation as illustrated in Figures 1-1 and 1-2. The same process parameters apply, although operating techniques differ.

In the anaerobic process the organic solids are first liquified. The organic material is then broken down by the action of two different groups of bacteria living together in the same environment. One group consists of microorganisms commonly referred to as acid formers. The second group, which utilize the acid formed by the acid formers are methane fermenters, commonly referred to as methane formers.

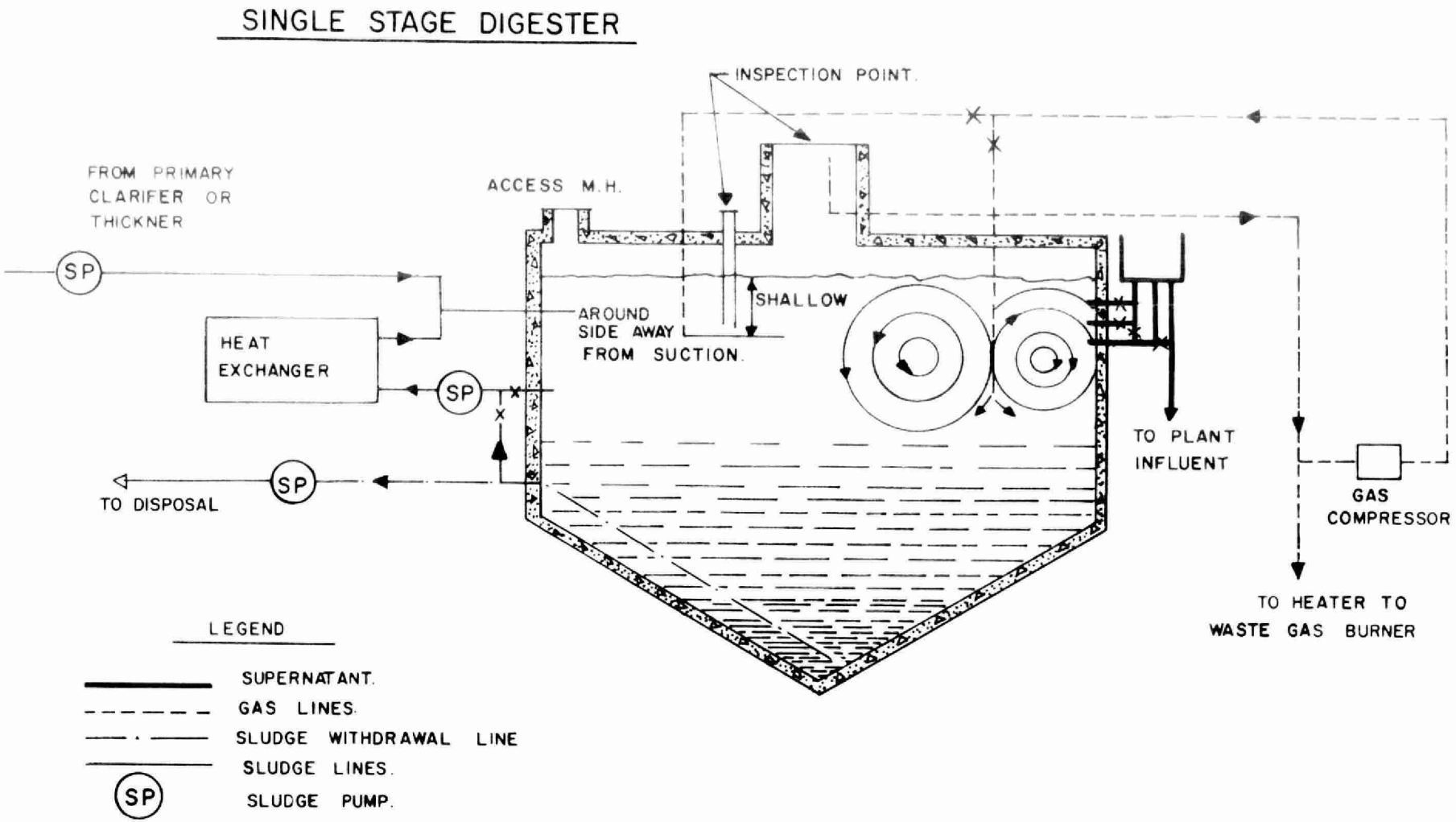

SINGLE STAGE DIGESTER
INSPECTION POINT.
FROM PRIMARY CLARIFER OR THICKNER
ACCESS M.H.
SP
HEAT EXCHANGER
SP
AROUND SIDE AWAY FROM SUCTION.
SHALLOW
TO PLANT INFLUENT
GAS COMPRESSOR
SP
TO DISPOSAL
TO HEATER TO WASTE GAS BURNER
LEGEND
SUPERNATANT.
GAS LINES.
SLUDGE WITHDRAWAL LINE
SLUDGE LINES.
SP
SLUDGE PUMP.

FIGURE 1-1

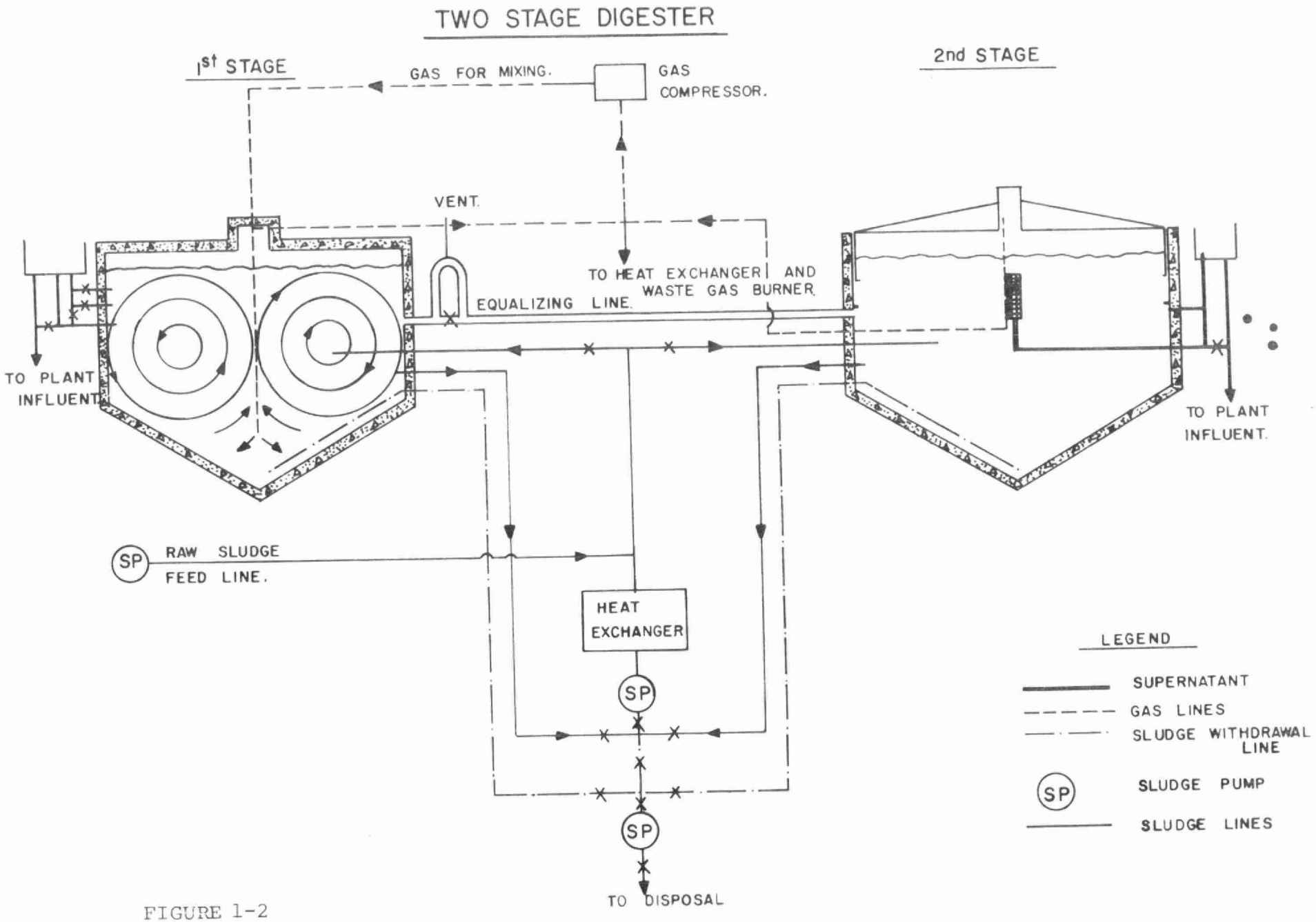

TWO STAGE DIGESTER
1st STAGE
2nd STAGE
GAS FOR MIXING.
GAS COMPRESSOR.
VENT.
TO HEAT EXCHANGER AND WASTE GAS BURNER.
EQUALIZING LINE.
TO PLANT INFLUENT.
TO PLANT INFLUENT.
SP
RAW SLUDGE FEED LINE.
HEAT EXCHANGER
SP
SP
TO DISPOSAL
LEGEND
SUPERNATANT
GAS LINES
SLUDGE WITHDRAWAL LINE
SP
SLUDGE PUMP
SLUDGE LINES

FIGURE 1-2

The digestion process is normally described as occurring in three steps, although these occur continuously and, for all practical purposes, simultaneously:

1. Acid fermentation
2. Acid regression
3. Alkaline fermentation

Acid Fermentation

During the acid fermentation stage, the organic matter is broken down to volatile fatty acids, primarily acetic, butyric and propionic acids, which results in a drop in pH and causes putrefactive odours. The organisms primarily responsible for this stage of digestion are tha acid formers. As a rule, the acid formers are very vigorous producers and are less sensitive to environmental factors than the methane formers.

Acid Regression

During the acid regression stage, decomposition of volatile acids and soluble nitrogenous compounds occurs which result in the formation of the following principal compounds:

1. ammonia
2. amines
3. acid carbonates

During this stage the pH will tend to increase.

Alkaline Fermentation

During the alkaline fermentation stage, destruction of nitrogenous compounds and cellulose occurs. The volatile acids, produced during stage 1 of the process are broken down to produce carbon-dioxide (CO_2), methane (CH_4) and water. The principal organisms responsible for this process are the methane formers, a slower reproducing bacteria, and much more sensitive to their environment than the acid formers.

ANAEROBIC DIGESTION PROCESS

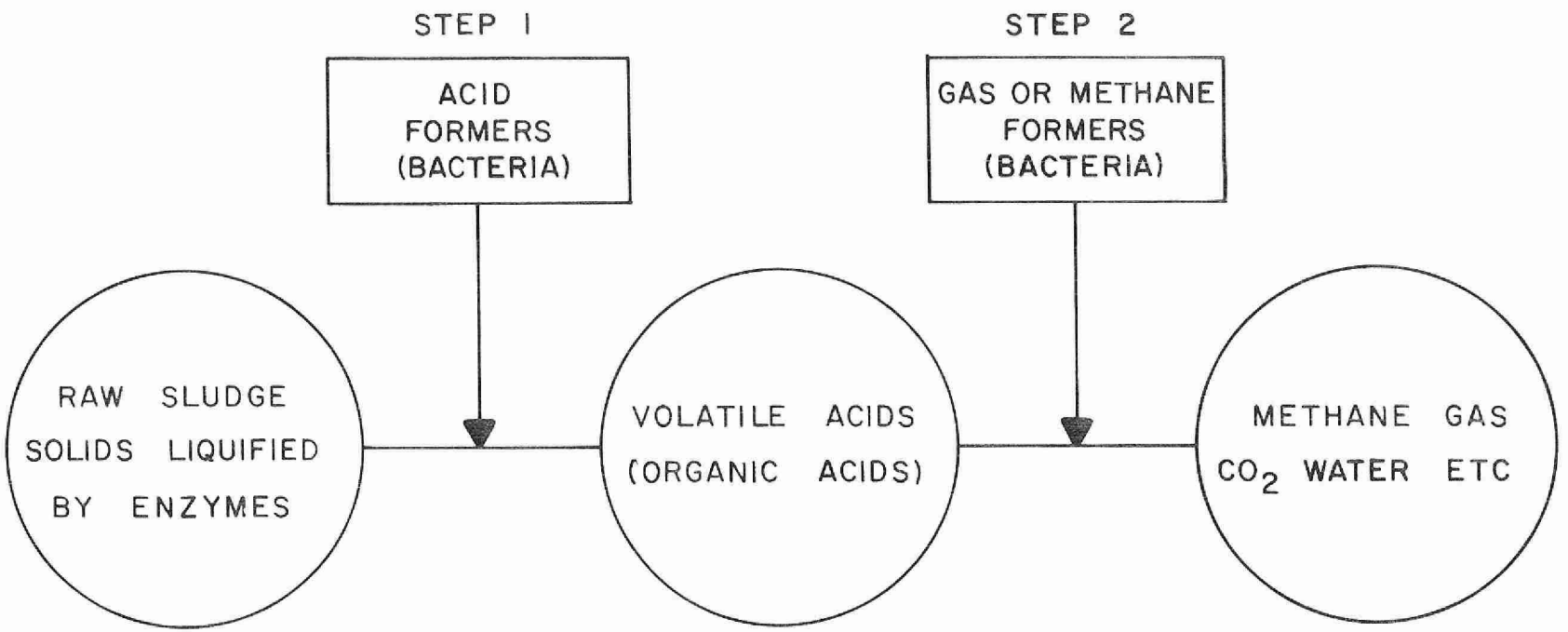


FIGURE 1-3

To summarize, the anaerobic digestion process is shown pictorially in Figure 1-3.

MIXING

Mixing is an important factor in the process and proper maintenance of the associated equipment is essential. Efficient mixing ensures effective digester operation and greatly speeds up the process. The main function of mixing is to:

1. Utilize as much of the total volume of the digester as possible.
2. Quickly distribute the raw sludge throughout the digester and put the microorganisms in contact with fresh food sources as quickly as possible.
3. Achieve good pH control by distributing buffering alkalinity throughout the digestion tank.
4. Obtain the best possible distribution of heat throughout the tank.
5. Minimize the deposition of grit and inert solids on the bottom or float scum material to the top.

Mixing can be accomplished by various means using:

1. mechanical mixers
2. digester gas recirculation

Some mixing action is also achieved by recirculating sludge through the heat exchanger.

Mechanical Mixing

The propeller-type mixers are found mainly on fixed-cover digesters. Normally, two or three of these units are supported on the roof of the tank. Explosion proof motors drive the mixers. A typical propeller-type mixer is shown in Figure 1-4. The draft tubes are steel and range from 18 to 24 inches in diameter. The top of the draft tube has a rolled lip and is located approximately 18 inches below the normal liquid level in the tank. The bottom of the draft tube may be straight or equipped with a 90-degree elbow. The 90-degree elbow type is placed so that the discharge is along the outside wall of the tank to create a whirlpool action.

The mixer propeller is located about two feet below the top of the draft tube. This type of unit usually has a reversible motor so that the propeller may be rotated in either direction. In one direction the contents are pulled from the top of the digester and forced down the draft tube to be discharged at the bottom. By operating the motor in the opposite direction, the digested sludge is pulled from the bottom of the tank and is then discharged over the top of the draft tube near the surface.

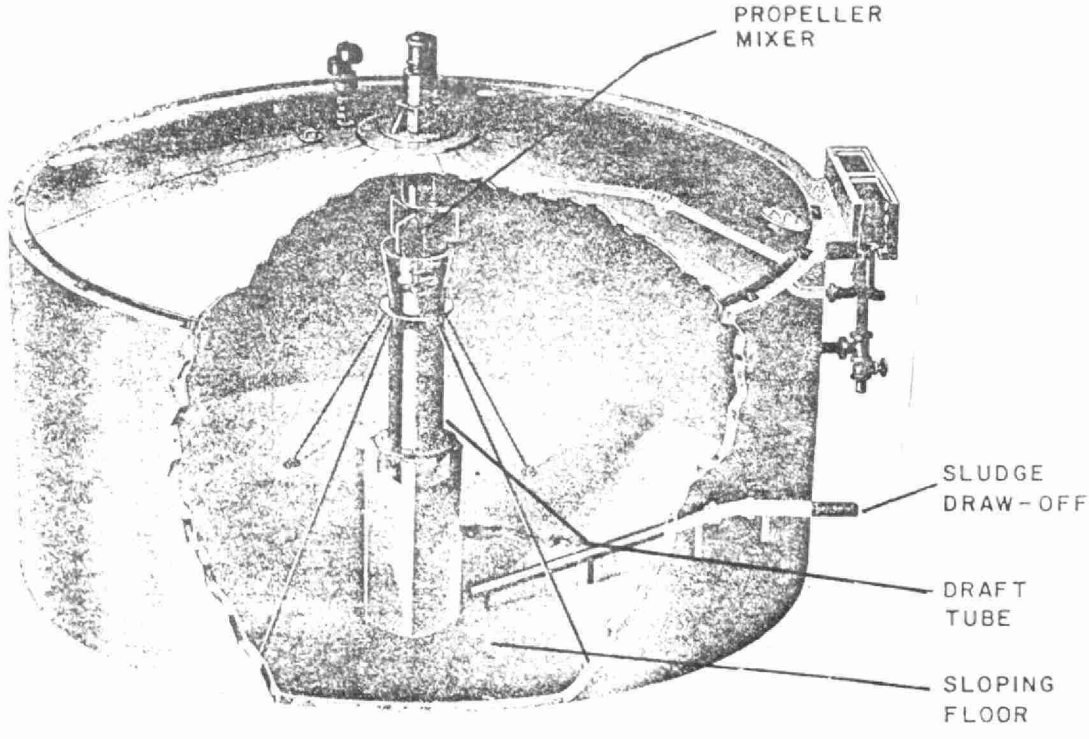


Figure 1-4 MECHANICAL MIXER
(COURTESY OF DORR-OLIVER, INC.)

Mechanical mixers are sometimes subject to shaft-bearing failure due to the abrasiveness of the sludge, and corrosion by hydrogen sulphide present in the digester gas. Maintenance consists of lubrication and, if belt-driven, adjustment of belt tension.

Pumps are sometimes used to mix digesters. This method is common in smaller tanks. When external heat exchangers are utilized, a larger centrifugal pump is used to recirculate the sludge and discharge it back into the digester through one or two directional nozzles at the rate of about 200 to 1000 gpm.

Maintenance of the recirculating sludge pump requires normal lubrication and a good pump-shaft water sealing system. The digested sludge is abrasive and pump packing, shaft wearing rings, and impellers are rapidly worn. Another problem associated with pump mixing is clogging of the pump impeller with rags, plastic materials, rubber goods and other pieces of material which can wind around the impeller causing it to plug.

It is very important to check pump operation several times a day. Pressure gauges should be installed on the pump suction and discharge pipes. If a rapid increase in pressure differential is seen, the operator has an indication that pump clogging has occurred.

Mixing by Digester Gas Recirculation

In these systems the digester gas is fed from the gas dome of the digester, compressed in the blowers and fed to the gas lift mixing devices inside the primary digesters. Mixing of the sludge is accomplished as the gas rises from the devices to the surface of the sludge.

Dual gas compressors, (100% standby), are usually supplied either in ventilated housing on the digester roof or in a separate gas room. The compressors are a source of high maintenance and can be any type of positive displacement blower or vane-type compressor, with explosion proof motors and electrical auxiliaries. Hermetically sealed blowers and

motors are also being used, to overcome the seal leakage problem.

The main types of gas lifting devices in common use are:

1. Bubble Guns
2. Central Mixing Draft Tube and Pipes
3. Gas Injection Pipes
   a. Roof mounted
   b. Floor mounted

Bubble Guns

The bubble gun system uses several gun assemblies located at the half-radius of the digester and evenly spaced around the circle. The number of guns varies from 3 to 6 as the digester diameter increases from 40 to 110 feet. The gun (Fig.1-5) consists of a 12" Ø vertical stack mounted on a tripod attached to the floor of the digester with a bubble generating device at its lower end. The gas fed into the generator exits every few seconds in large single bubbles that completely fill the stack and act as pistons to force the liquid above them to the surface. As the bubbles move up the stack, more liquid is drawn in behind them, continuing the gas lift pumping action.

Any maintenance on this system requires the digester to be taken out of service.

Central Mixing Pipes and Draft Tube

This system employs one large draft or eductor tube centrally located in the digester, with numerous 2" diameter gas pipes feeding fine bubble spargers at their lower end, (Fig. 1-6). The eductor tube diameter varies from 18" to 72" as the digester diameter increases from 40 to 110 ft. Since the gas is released at about half the digester depth, lower blower pressures are required than with other systems. There is the tendency for circulation short-circuiting with this system, particularly with larger digester diameters.

Recent testing of a new installation in a 110 ft. diameter digester, indicated that only 50% of the contents were being mixed.

Gas Injection Pipes

The roof mounted injection pipe system employs several 2 inch diameter pipes, attached to the digester roof and extending down to within a foot of the digester floor. Compressed gas, escaping from the lower end of the pipe creates an area of less density and sets up a pumping action that circulates the sludge in the local area. The number of injection pipes varies from 5 to 12 as the digester diameter increases from 40 to 110 ft. The pipes are located at .6 to .75 of the digester radius from the centre, with one pipe near the centre (Fig.1-7). Each injection pipe has a 4" diameter pipe surrounding the 2 inch pipe, extending downward into the sludge to form a gas seal (Fig.1-7). The injection pipes can then be easily disconnected and removed for maintenance or replacement without taking the digester out of service. This system can also be assembled to a floating digester cover.

The floor mounted diffuser system offered by Chicago Pump consists of several diffusers bolted to the floor and grouped in the centre of the primary digester, with each diffusers varies from 6 to 16 as the digester diameter increases from 40 to 110 ft. The diffuser itself consists of a cast iron box, 7 inches square by 12" deep without a top, with the 1" gas line attached to one side and terminating 2" inside the box (Fig.1-7). Any maintenance work would require complete dewatering and cleanout of the digester. Low compressor horsepower requirements are claimed. Each gas feed line is piped to an orifice plate flowmeter in the gas room for balancing the gas volumes to each diffuser.

The above noted quantities and spacings of the mixing devices are as recommended by the equipment suppliers. One

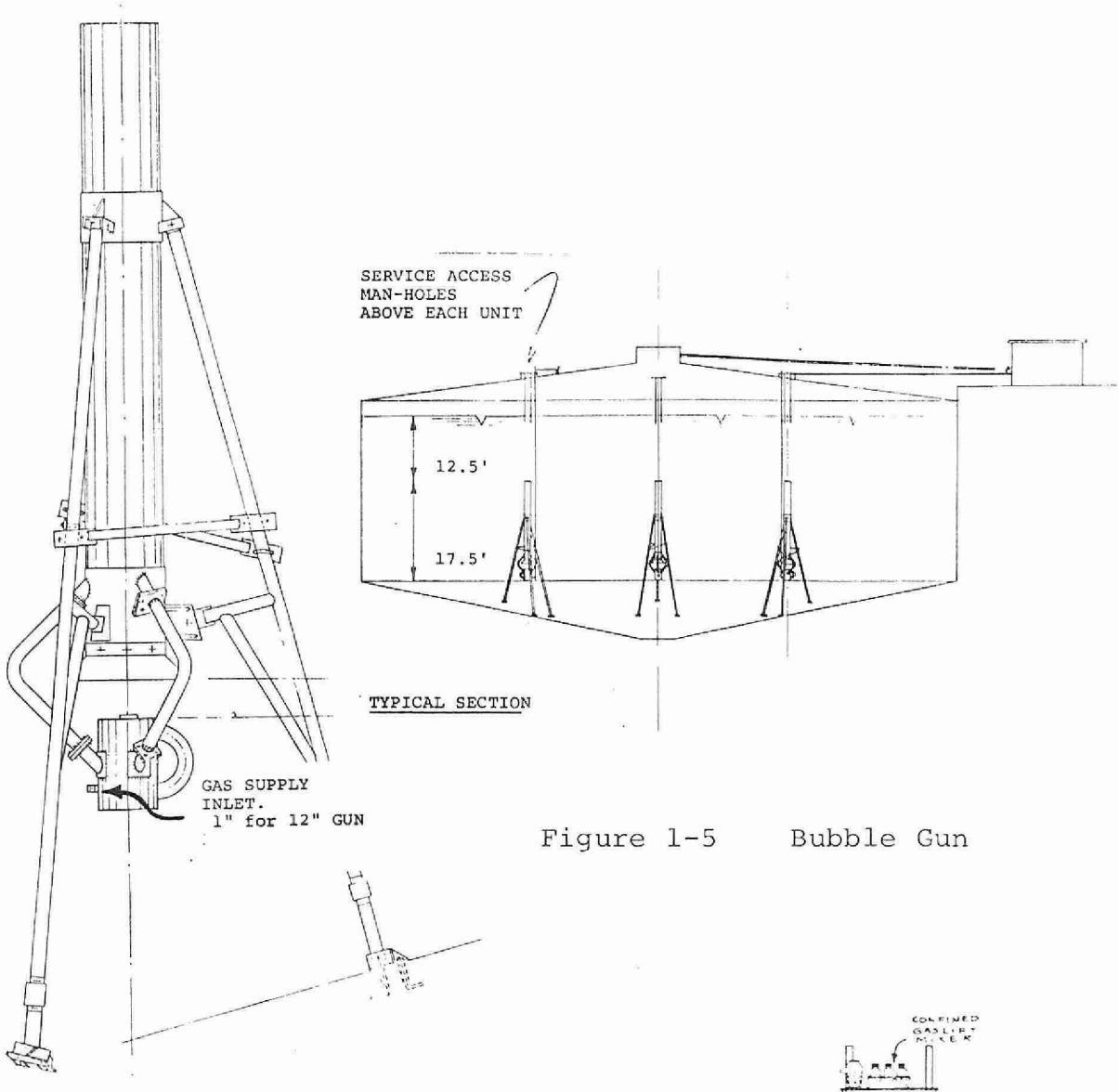


Figure 1-5 Bubble Gun

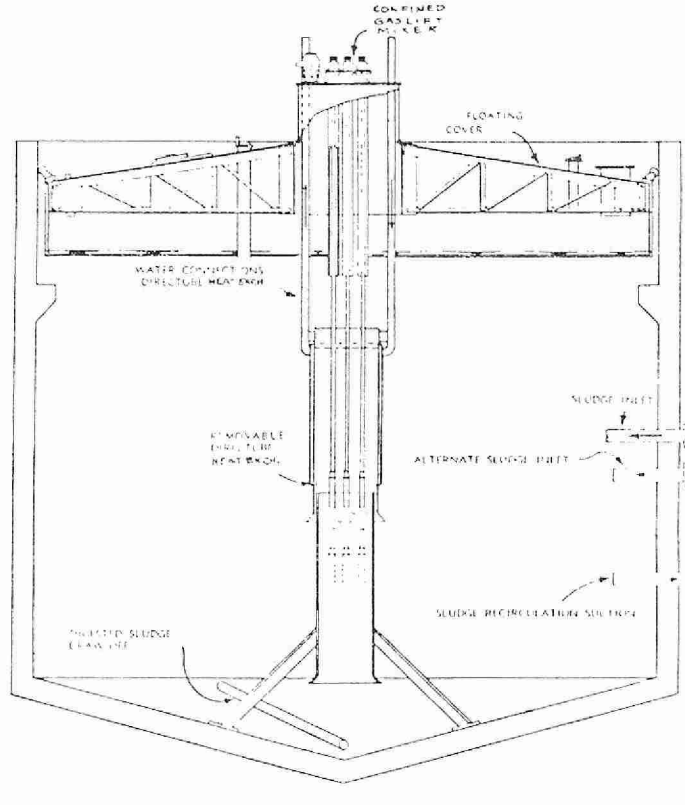
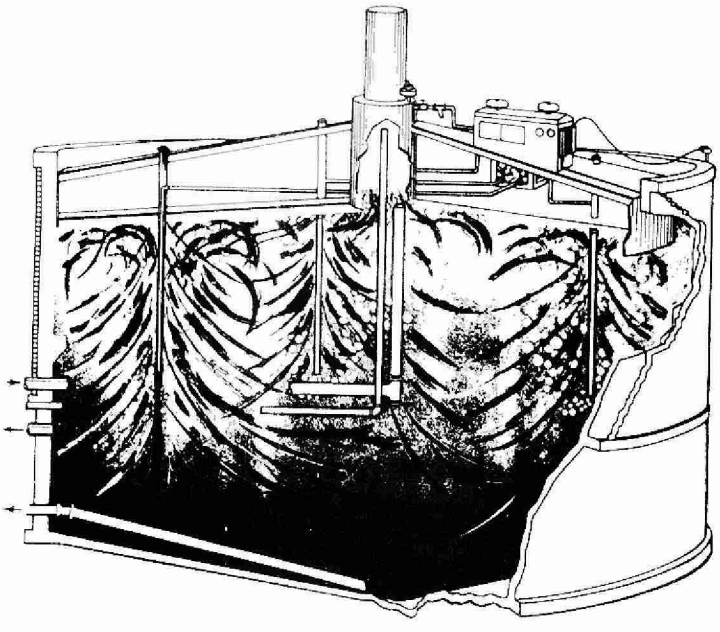
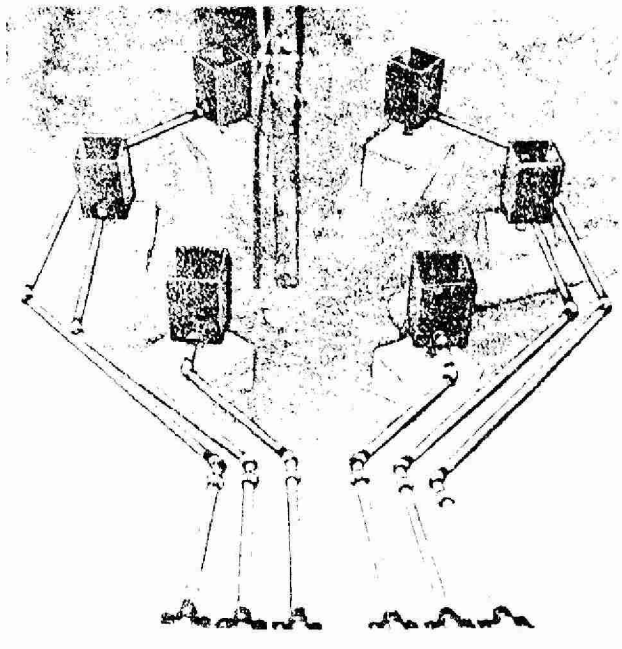


Figure 1-6
Central Mixing Draft Tube

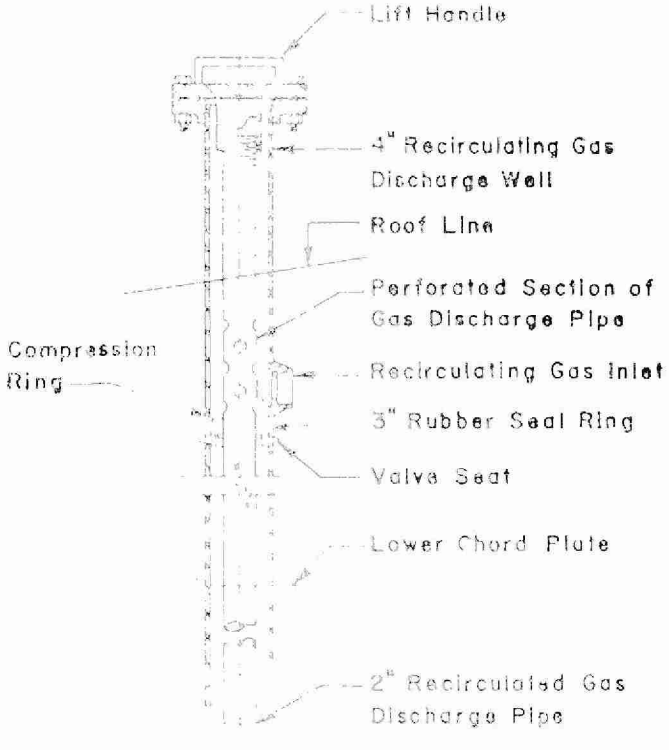
Figure 1-7 Gas Ejection Pipes



Roof Mount



Floor Mount



criteria for determining the mixing adequacy of a system is the horsepower expended per 1000 cu. ft. of volume. This figure now varies from 0.02 to 0.25 HP/1000 ft.^{3} (0.65 to 6.5 KW 1000 m^3) in existing installations. Operating experience to date indicates that all systems give inadequate mixing and further research in this direction is required.

All of the above systems have the advantage of no moving parts in the digester requiring maintenance. One supplier of gun-type mixers was offering 11 gauge metal in the stacks which rusted out in a few years. A minimum material thickness of .25 inches is now specified on new installations with some thought of changing to stainless steel to completely overcome the corrosion problem. Some systems have complicated rotary valves or solenoids on the gas supply lines to program the mixing devices on and off. Field experience indicates that mixing is inadequate in most digesters and full-time operation of all mixing equipment is the best method of operation. Gas lift equipment water pumping rates are usually determined by tests using clean water and it is not clear what factors should be used to de-rate the equipment when handling sludges of 3% to 10% or more, solids. Provision should be made for expansion and flexibility in the gas supply lines. Sometimes if the gas supply lines are mounted on the digesters metal roof and the bubble guns are attached to the floor, the gas lines will break off at the guns, because of the vertical expansion of the metal roof.

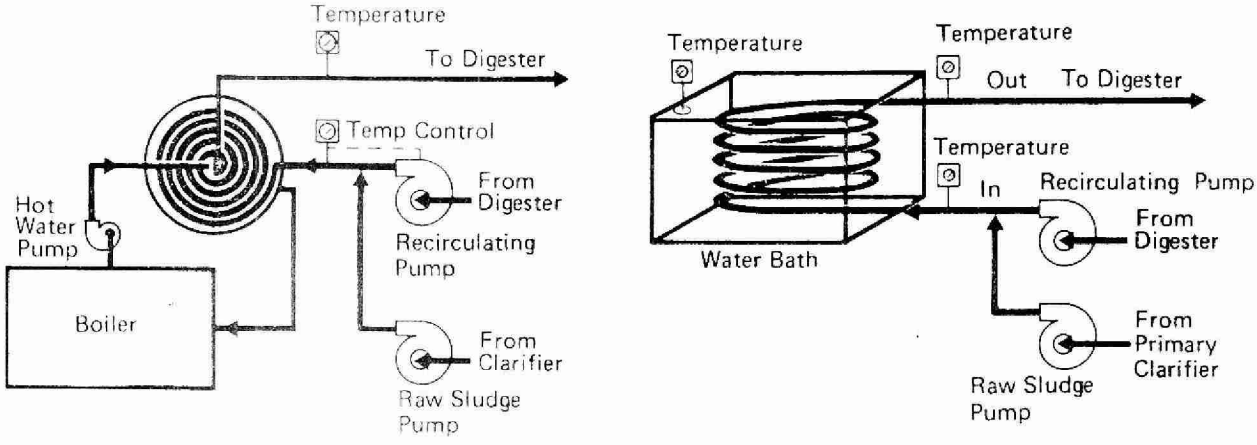
HEATING SYSTEMS

Digester heating, another important factor in the process, can be accomplished by:

1. Hot-water coils within the digester.
2. Recirculating sludge through an external heat exchanger
3. Direct contact of hot gas with sludge.
4. Steam injection.

See Figure 1-8

EXTERNAL HEAT EXCHANGERS



INTERNAL HEAT EXCHANGERS

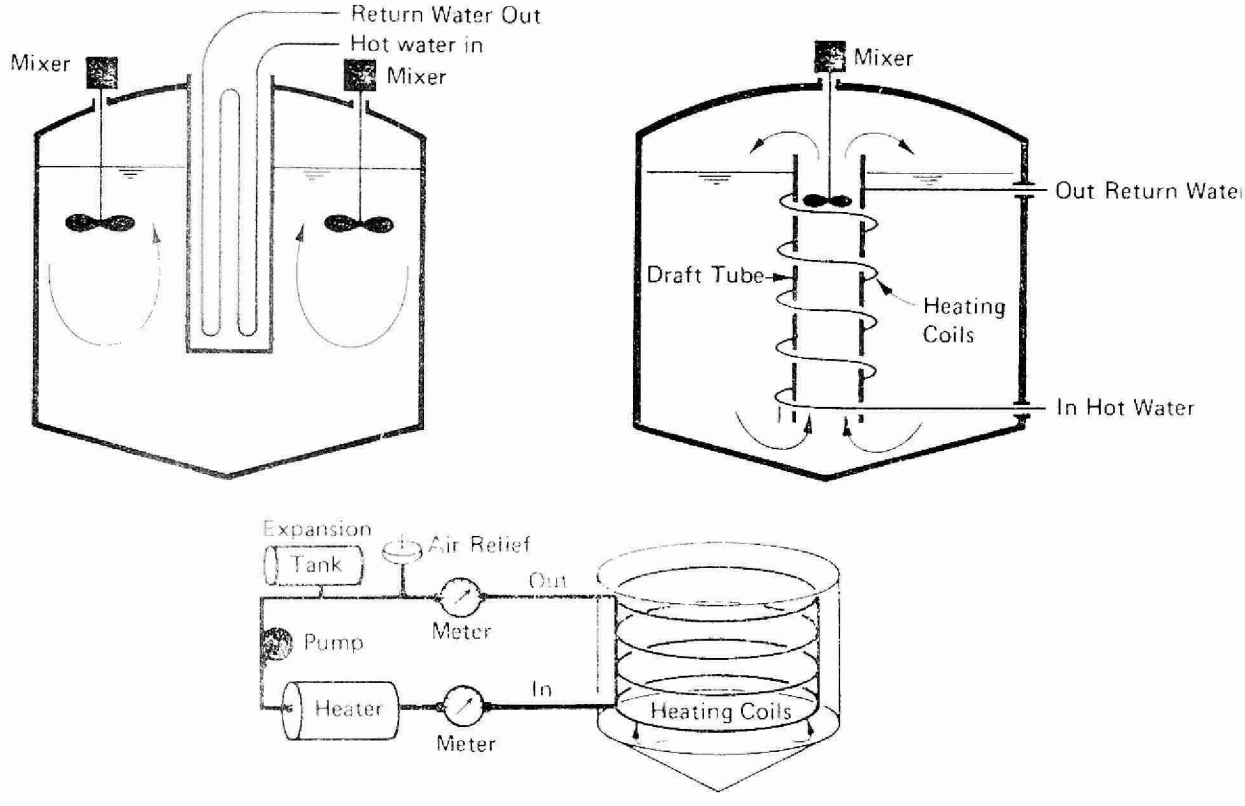


FIGURE 1-8 HEAT EXCHANGERS

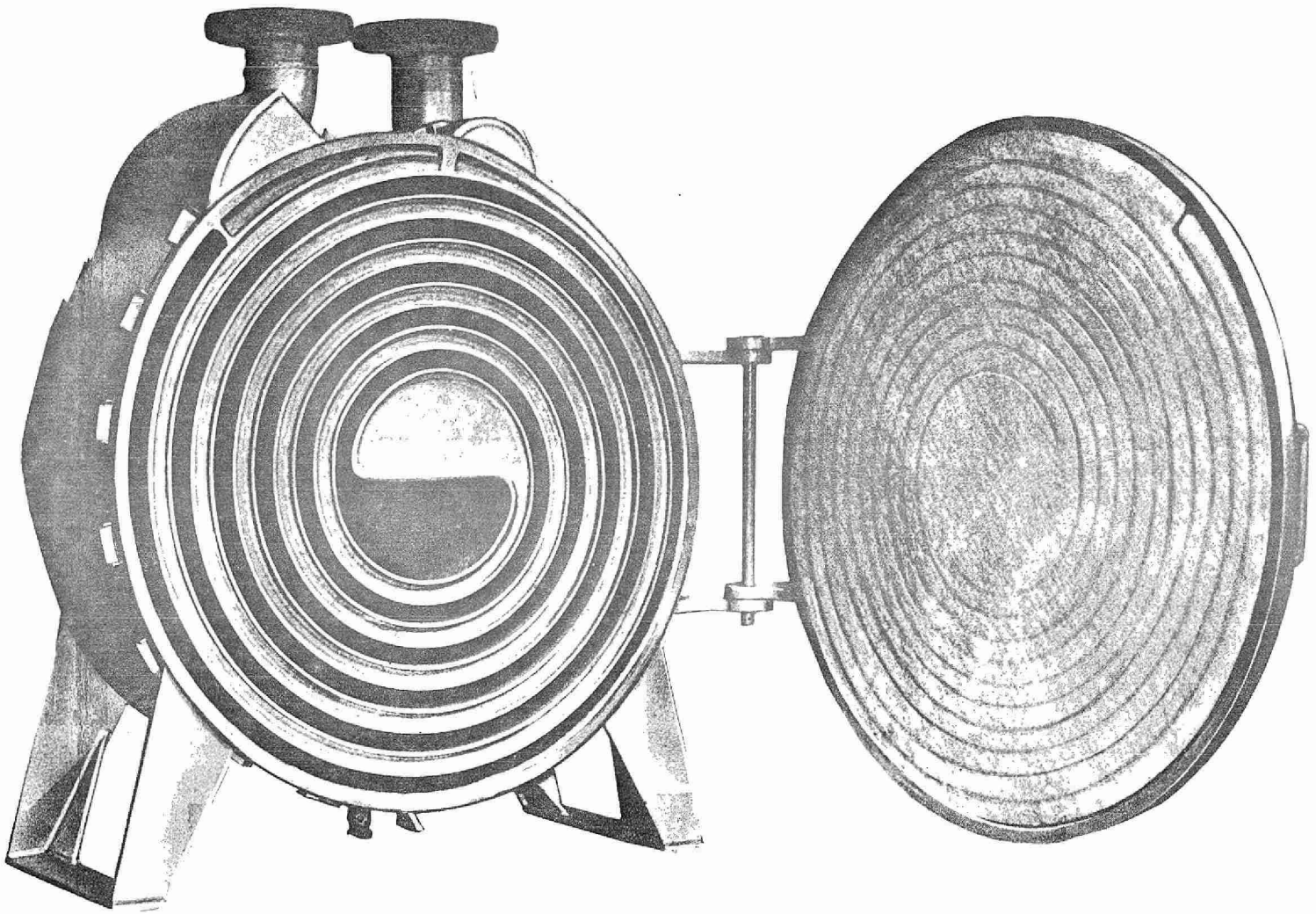


FIGURE 1-9 SPIRAL HEAT EXCHANGER

External Heat Exchanger

The most common system is the recirculation of sludge through an external heat exchanger. See Figure 1-9. Hot water is pumped from the boiler to the heat exchanger where it passes through a jacket while the recirculating sludge passes through an adjacent jacket, and receives heat from the water. Figure 1-10. In some heating installations the boiler and exchanger are combined in a single unit. There is some advantage in using external heat exchangers, as they help to control scum buildup and there is no hot water piping within the digester which can be corroded or caked up. The only disadvantage is that in a single stage digester system it is essential to stop sludge recirculation to allow the tank contents to stratify prior to the discharge of supernatant. This can result in an increased tendency to form a "cake" on the exchanger coils, or jackets due to localized overheating of the sludge.

Hot-Water Coil

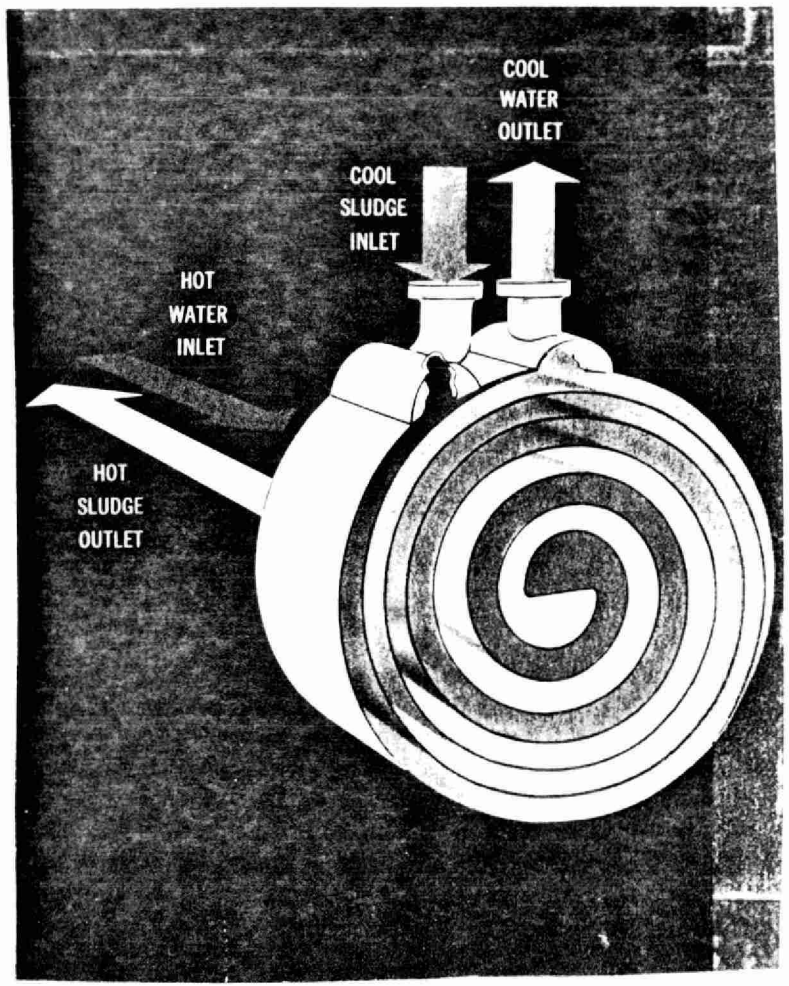
Hot-water coils within the digester consisting of pipes either horizontally or vertically attached to the inside wall of the digester is another method of heating digesters, although not too common in newer plants. This method tends to create a problem of sludge caking on the pipes and thereby effectively insulating them, thus reducing the amount of heat transferred. Where coils are used water temperatures entering the coils are limited to a temperature of 49° to 54°C with boiler temperatures held to no higher than 82°C to prevent excessive corrosion or caking of the sludge on the coils.

Direct Contact and Steam Injection

Direct contact of hot gas with sludge by steam injection methods have been used in the past with varying degrees of success. However, these systems are rarely installed in current practice.

SPIRAL HEAT EXCHANGER

PATTERN OF FLOW



SUBJECT:

DIGESTER GAS SYSTEM

TOPIC: 2

COMPONENTS

OBJECTIVES:

The trainee will be able to:

1. Identify components of a typical low pressure digester gas collection system.
2. Recall the function of each component of a digester gas collection system.
3. Recall the maintenance requirements for components of a typical digester gas collection system.
4. Carry out an inspection of a digester gas system to determine maintenance requirements.

COMPONENTS

DIGESTER GAS COLLECTION SYSTEM

GENERAL

As a result of the digestion process, digester gas is collected in the dome of the digester and is transferred to its point of use through piping along which are installed various safety devices, condensate collectors, pressure regulators and metering systems. The low pressure gas (5-9 in. water column) is usually used as a fuel for boilers or vented through a waste gas burner to atmosphere. In larger installations, the low pressure gas may be compressed and stored in a large gas receiver to be used in dual fuel engines (which drive electrical generators) whose requirements are generally in the order of 30 psi or greater.

A schematic diagram of a multiple digester gas system is shown in Figure 2-1. Extracts of draft code CGA B105 Installation Code for Digester Gas Systems pertaining to components is attached as Appendix A.

COMPONENTS

Digester Covers

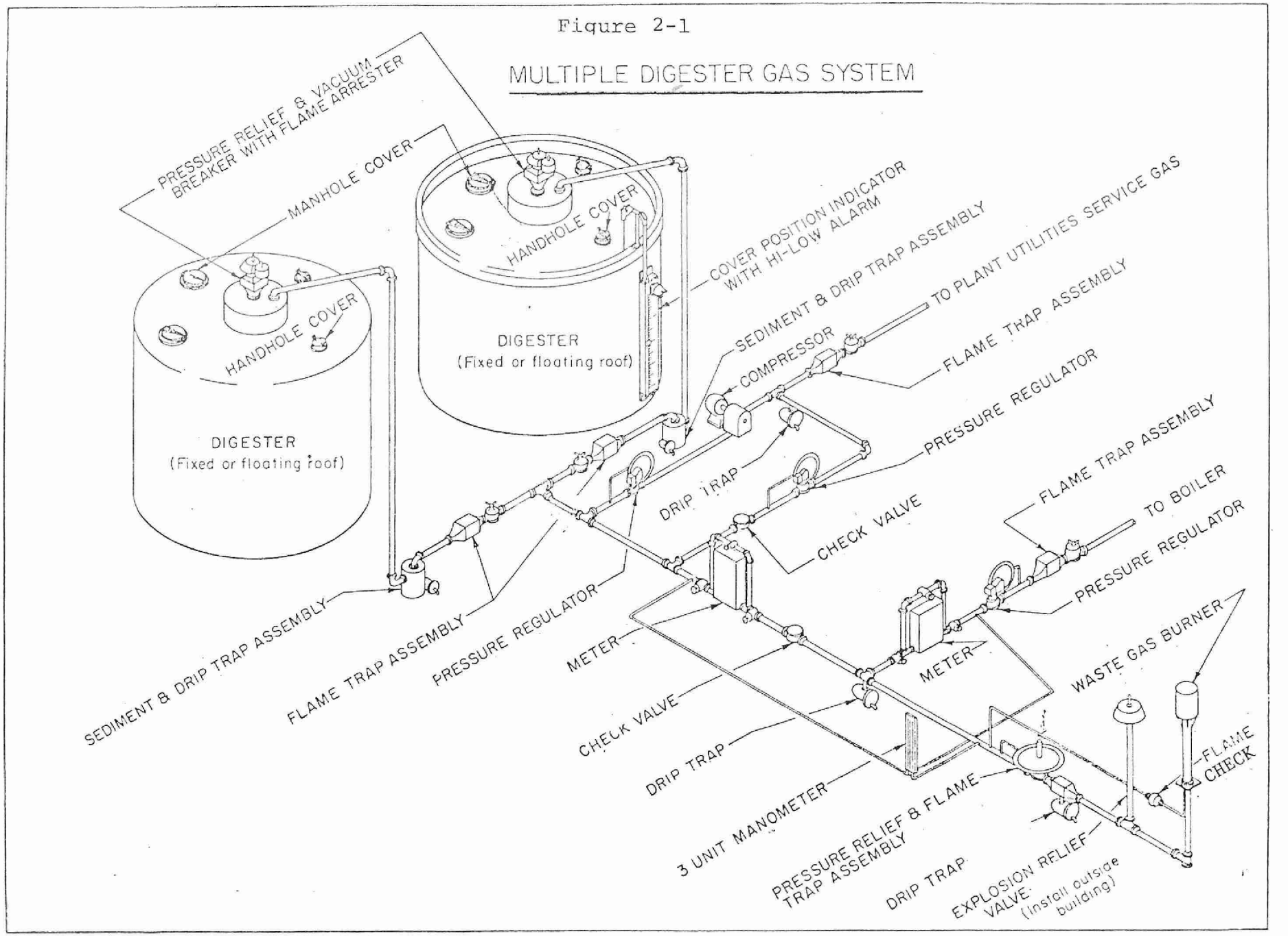
The cover on the digester serves several purposes:-

1. As a superstructure for mixing equipment.
2. Support for safety devices - pressure and vacuum relief valves, flame arrestor.
3. As a gas dome for the accumulation and collection of gas; storage space for gas produced.

There are three major types, fixed, floating and gas holder.

The fixed cover, Figure 2-2, may be concrete or metal. It can be seriously damaged if the pressure relief valve fails, supernatant overflow line plugs and the liquid level continues to rise. Pressure inside the tank can lift the cover off the walls, necessitating tank draining and expensive repairs. A water seal may be used to protect the tank. If excess pressure

Figure 2-1


MULTIPLE DIGESTER GAS SYSTEM
PRESSURE RELIEF & VACUUM BREAKER WITH FLAME ARRESTER
MANHOLE COVER
HANDHOLE COVER
DIGESTER
(Fixed or floating roof)
HANDHOLE COVER
DIGESTER
(Fixed or floating roof)
COVER POSITION INDICATOR WITH HI-LOW ALARM
SEDIMENT & DRIP TRAP ASSEMBLY
COMPRESSOR
TO PLANT UTILITIES SERVICE GAS
FLAME TRAP ASSEMBLY
PRESSURE REGULATOR
DRIP TRAP
CHECK VALVE
FLAME TRAP ASSEMBLY
TO BOILER
PRESSURE REGULATOR
WASTE GAS BURNER
SEDIMENT & DRIP TRAP ASSEMBLY
FLAME TRAP ASSEMBLY
PRESSURE REGULATOR
METER
METER
CHECK VALVE
DRIP TRAP
3 UNIT MANOMETER
PRESSURE RELIEF & FLAME TRAP ASSEMBLY
DRIP TRAP
EXPLOSION RELIEF VALVE (Install outside building)
FLAME CHECK

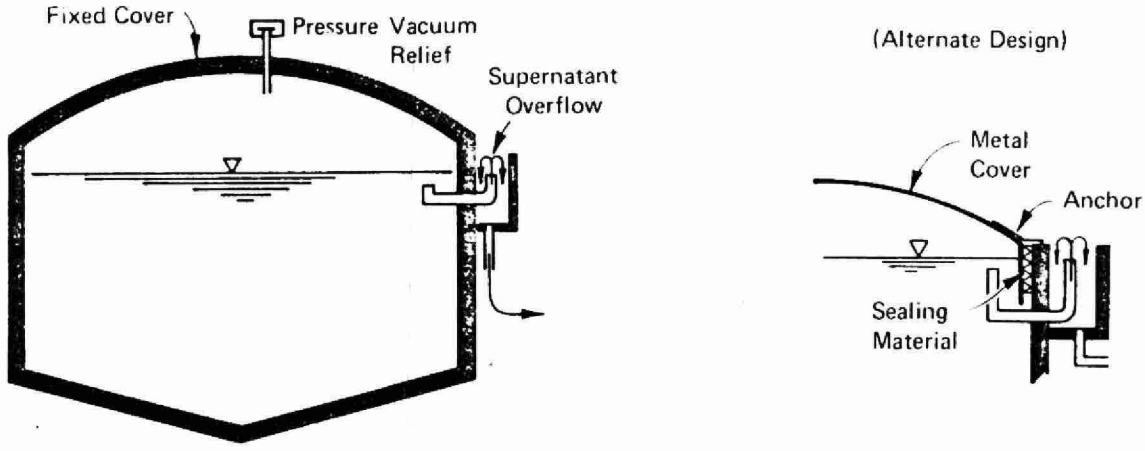


FIGURE 2-2 FIXED COVER

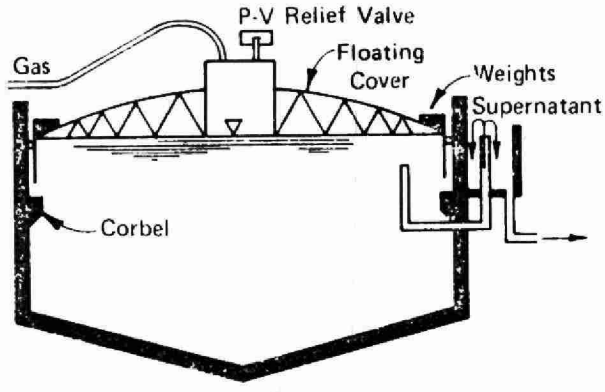


FIGURE 2-3 FLOATING COVER

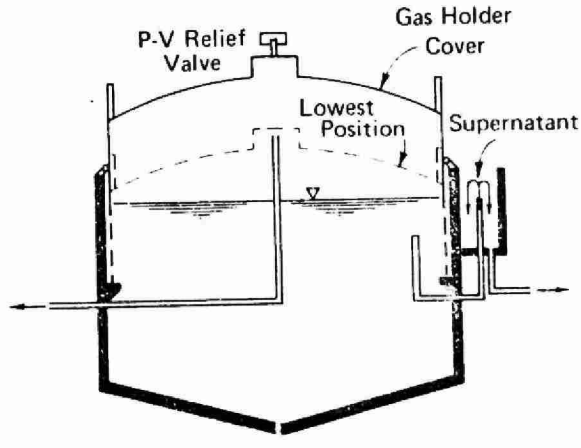


FIGURE 2-4 GAS HOLDER COVER

builds up, the gas will escape around the water seal. If a vacuum develops, air enters the tank breaking the seal.

The floating cover, Figure 2-3, is subject to the same hazards as the fixed cover. The cover floats on the surface of the sludge rising or falling as the level changes. Roller guides must be maintained in smooth operating condition. If an excessive amount of sludge is pumped in, the cover can be floated over the wall. They may also collapse if the vacuum relief valve fails. This type of failure is most prevalent during freezing weather.

The gas holder cover, Figure 2-4, is used to store gas as it is produced. The pressure developed inside the tank causes the cover to lift as much as six feet or more above its minimum height. It has a much longer skirt than the floating type.

After a digester clean out the digester roof should be checked internally and externally for corrosion. The rods and braces should be checked and repaired where required. Internal piping should be checked and repaired where necessary. Mixing equipment, mechanical or gas re-circulation, should be checked and repaired if required. Free movement of floating roofs should be checked.

After all equipment has been maintained, the digester should be filled with water to the operating level, the Pressure and Vacuum Relief Valve removed and the opening blanked off. The digester should now be brought up to 1½ times its operating pressure by either air pressure or raising the water level to a higher level or both. This test pressure should be held for the required amount of time as outlined in the draft digester gas installation code C.G.A. B.105.

During the test the roof area should be sprayed with a soap solution (3 ounces of detergent per gallon of water) to detect the presence and location of any leaks. If the test proves satisfactory the digester can be put into service.

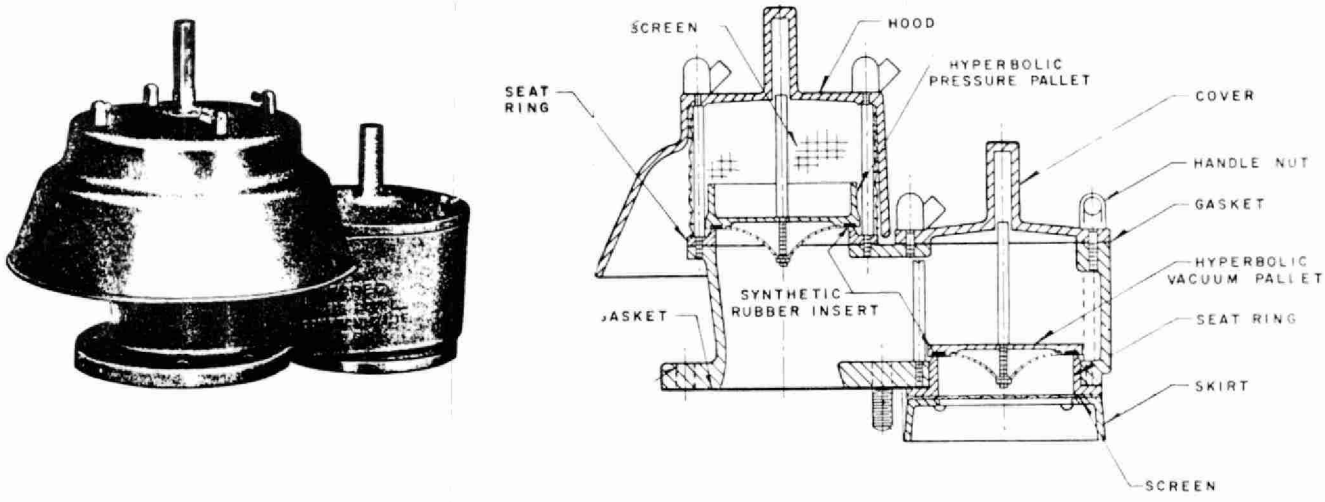


FIGURE 2-5 PRESSURE AND VACUUM RELIEF VALVES

Pressure Relief and Vacuum Relief Valves

On the roofs of the digesters there are pressure and vacuum relief valves. The valves are installed to prevent damage to the roof by excessive pressure or vacuum. For example, should it be necessary to perform maintenance upon flame arresters, meters, or other gas equipment, a plug valve may be closed upstream to isolate the section under maintenance or repair. The gas produced constantly in the digester then has nowhere to go and exerts pressure on the digester roof. The pressure relief valve usually set to open at around 15 inches of water column, will open when the roof pressure reaches this level and vent the gas to the atmosphere for the duration of the maintenance period.

The pressure relief valve and the vacuum relief valve (Figure 2-5) are attached to a common pipe, but each works independently. The pressure relief valve is equipped with a seat and weighted with lead washer weights. Each weight is stamped with its equivalent water column height such as 1" H_2O or 3" H_2O. There should be sufficient weights, combined with the weight of the pallet, to equal the designed holding pressure of the tank. To calculate the weight requirements see

Appendix B. The gas pressure is normally retained between six inches and eight inches of water. If the gas pressure in the tank exceeds the upper limit setting, then the valve will open and vent to the atmosphere, through the pressure relief valve. This should occur before the water seal blows out.

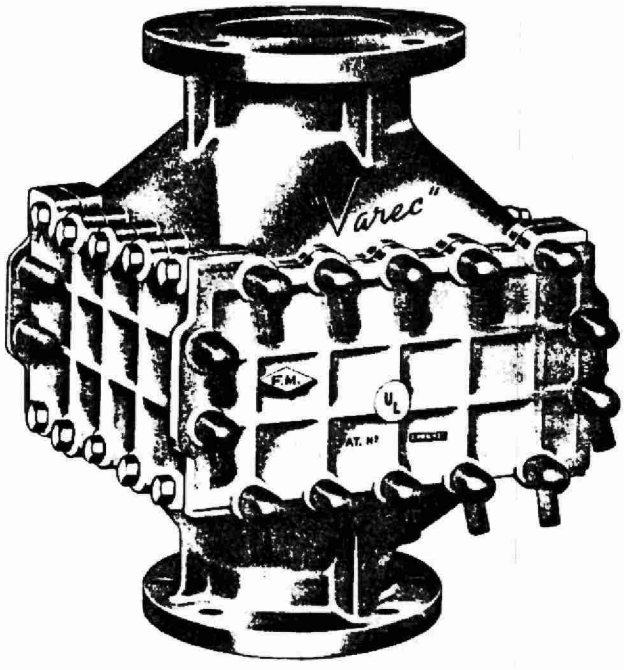
On some occasions when digested sludge is being trucked away, or when there is a sharp drop in temperature, it is not always possible to maintain gas pressure in the digesters and a slight vacuum may be exerted on the roofs. At these times the vacuum relief valve opens, admitting some air to equalize pressure. Occasionally there are manual valves installed upstream of the pressure and vacuum relief valve. This is a design defect as it is potentially very dangerous should the manual valve be left closed through oversight. Where these valves are installed, they must be removed in accordance with the direction from the Ministry of Consumer and Commercial Relations.

The vacuum relief valve operates similarly to the pressure relief valve except that it relieves negative pressure to prevent the tank from collapsing. Unnecessary manual operation of either valve is undesirable. Digester gas will mix with air and possibly lead to an explosion, outside the tank if the pressure relief valve is opened, and inside the tank if the vacuum relief valve is opened.

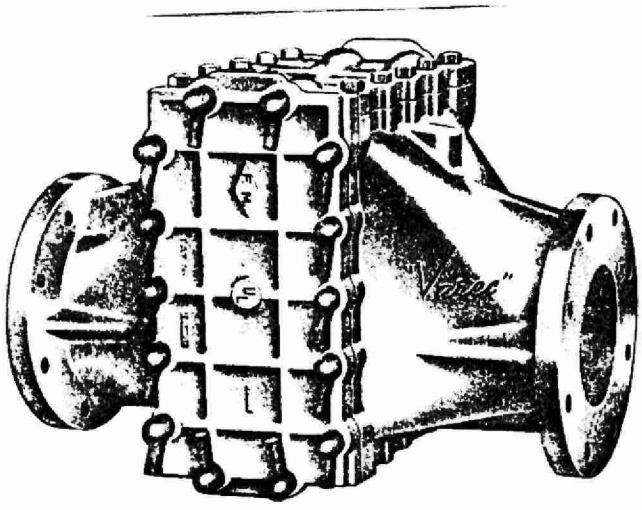
These two valves should be inspected at least every three months for proper operation. They should be dismantled yearly. Valve faces, seats, guides, spring tension and weights should be inspected, repaired or adjusted as necessary.

Flame Arrestors

A typical flame arrestor is a rectangular box holding approximately 50 to 100 corrugated aluminum plates with punched holes. If a flame should develop in the gas line, it would be cooled below the ignition point as it attempted to pass through the baffles, but gas could flow through with little loss in pressure. See Figure 2-6.



HORIZONTAL TYPE



VERTICAL TYPE

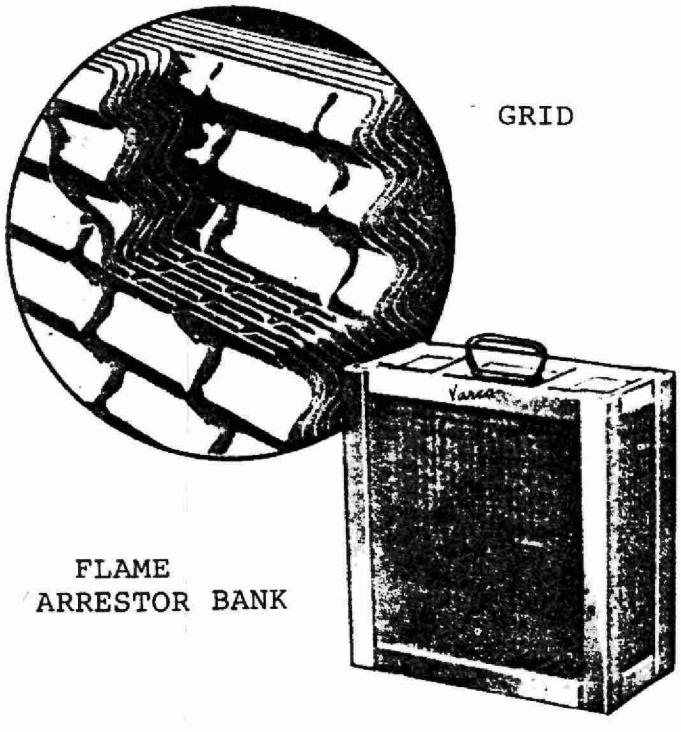


FIGURE 2-6 FLAME ARRESTOR

When coupled with a thermal valve, Figure 2-7, the assembly is called a flame trap assembly.

To prevent explosions, flame arrestors should be installed:

1. *Between the vacuum and pressure relief valves and the digester dome.*
2. *After the sediment trap on the gas line from digester.*
3. *At the waste gas burner.*
4. *Before every boiler, furnace, or flame.*

Flame arrestors should be serviced every three months by valving the gas off, pulling one end plate, and sliding the baffle cartridge out of the housing. A build-up of scale, salts from condensate, and residue build-up on the plates restricts gas flow.

The cartridge in the flame arrestor is designed to slide open so the baffles may be separated and washed without complete dismantling. When the unit is reassembled it should be tested for leaks by swabbing a soapsuds solution over potential leaky areas and inspecting for bubbles.

Thermal Valves

Another protective device always installed near a flame source and near the gas dome is a thermal valve. See Figure 2-7. This valve is round, with a weighted seat attached to a stem. The stem sits on a fusible plug of wax or metal, holding the seat up. If heat is generated by a flame, the fusible element melts at 260^{o}F and drops the stem and valve seat to cut off gas flow. Most valves are equipped with a wing nut on top of the valve body. If the wing nut is removed, it uncovers a glass tube which shows visually if the stem is up. If the stem cannot be seen, then the valve is removed and heated in boiling water to remove the melted fusible slug. A new slug is installed (slightly larger than an aspirin tablet), the stem replaced on top of it, and the valve is ready for service. These valves should be dismantled at least once a year to ensure that the stem is free to fall and not gummed up with residue or scale from the gas.

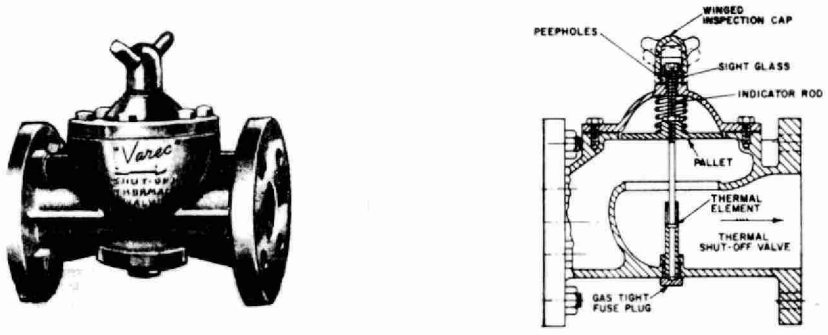


FIGURE 2-7 THERMAL VALVE

Sediment Traps

A sediment trap is a tank 12 to 15 inches in diameter and two to three feet in height. See Figure 2-8. The inlet gas line is near the top of the tank and on the side. The outlet line comes directly from the top of the sediment tank. The sediment trap is also equipped with a perforated inner baffle, and a condensate drain near the bottom. The gas enters the side at the top of the tank, passes down and through the baffle, then up and out the top. Moisture is collected from the gas in the trap, and any large pieces of scale are trapped before entering the gas system. The trap should be drained of condensate frequently but may have to be drained twice a day during cold weather, because greater amounts of water will condense and accumulate.

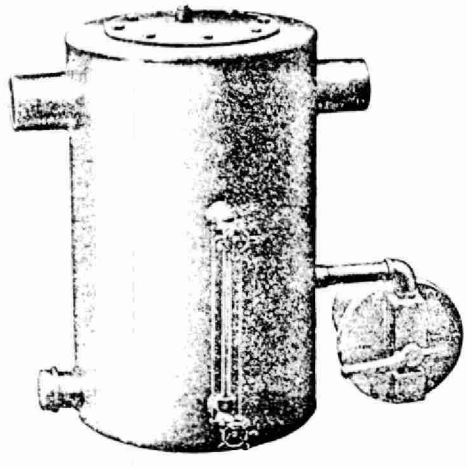


FIGURE 2-8 SEDIMENT TRAP WITH DRIP TRAP

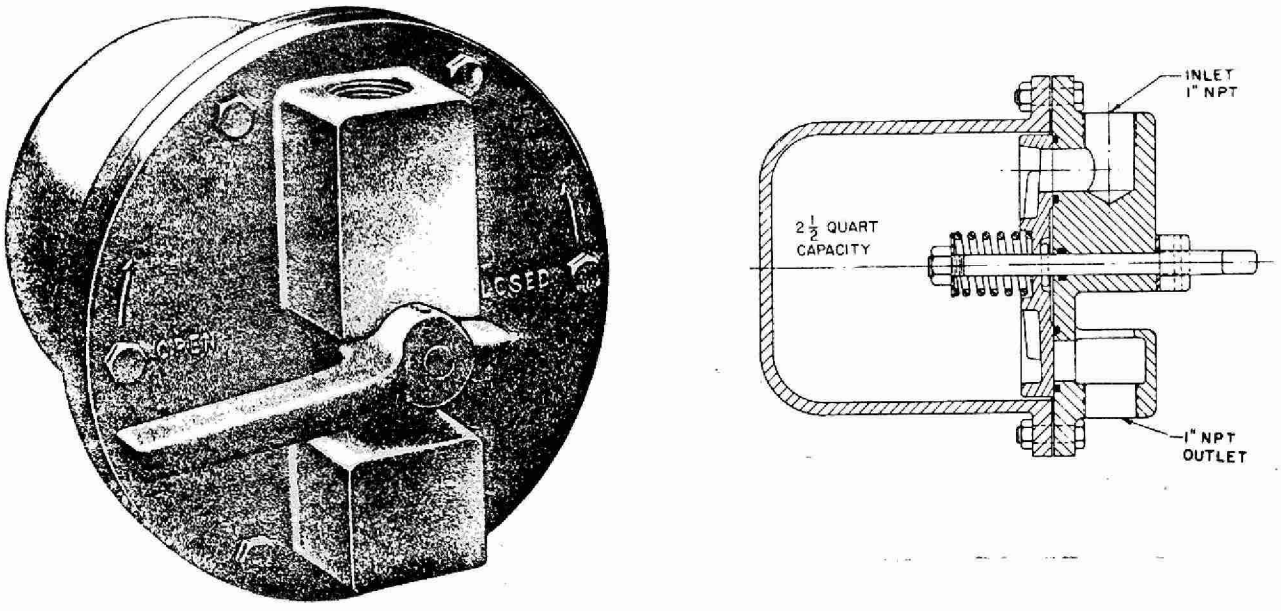


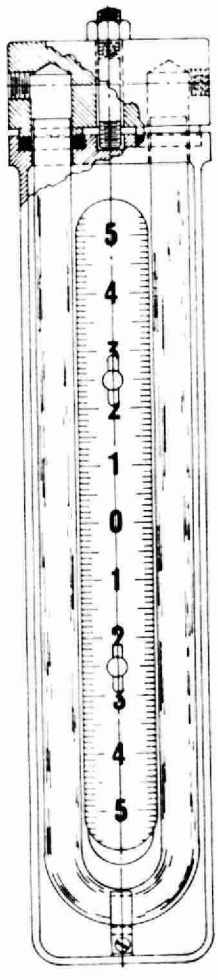
FIGURE 2-9 DRIP TRAP - ROTATING DISC TYPE

Drip Traps - Accumulators

Digester gas is quite wet and in traveling from the heated tank to a cooler temperature the water condenses. The water must be trapped at low points in the system and removed, or it will impede gas flow and cause damage to equipment such as compressors, and interfere with gas utilization. Traps are usually constructed to have a storage space of one to two quarts of water. All drip traps on gas lines should be located in the open air and be of the manual operation type. Traps should be drained at least twice a day and possibly more often in cold weather. Automatic drip traps are not recommended because they are equipped with a float and needle valve orifice. Corrosion, sediment, or scale in the gas system can keep the needle from seating. The resulting leaks may create gas concentrations with a potential hazard to life and equipment. See Figure 2-9

The accumulators are simply large drums installed in piping systems, which allow the gas to expand momentarily before continuing to flow downstream. Expansion results in a decrease in gas temperature, causing the moisture to condense and collect in the accumulator.

Water accumulators must be equipped with a manual drip trap or have other means of draining which will maintain a reliable gas seal.

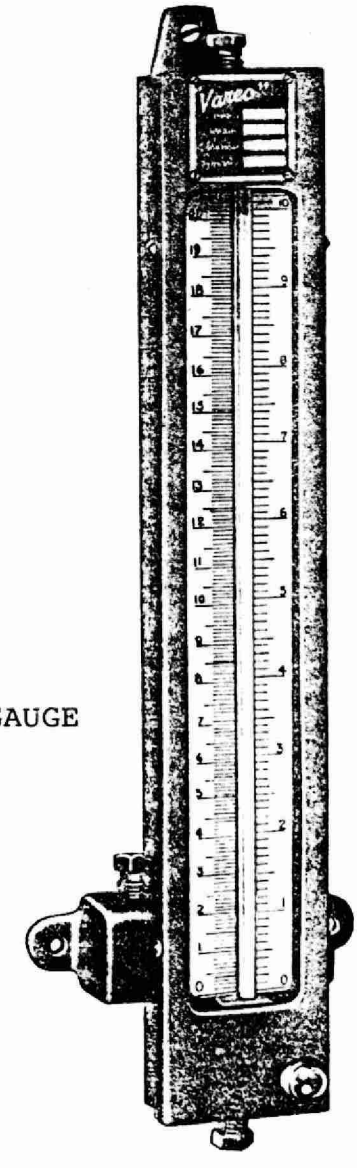


U TUBE

TYPE

FIGURE 2-10

MANOMETERS



WELL TYPE

PRESSURE GAUGE

Manometers

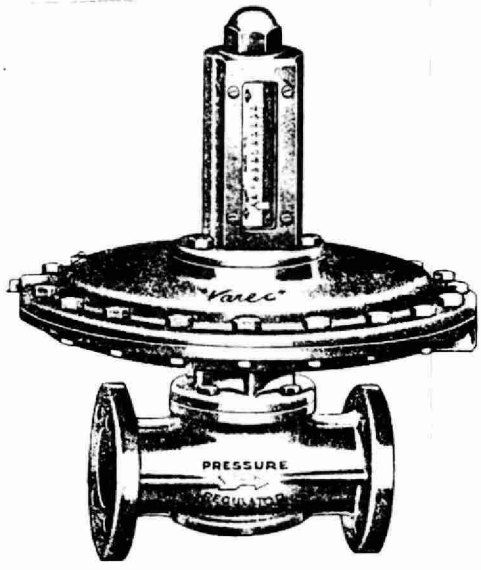
Manometers are installed in the gas piping system, usually on the digester gas line, the service line to the boiler, and the line to the waste gas burner. See Figure 2-10. The manometers are normally oil filled and read pressure in inches of water column. Readings should be noted and recorded daily. The manometer readings are useful in showing what is occurring in the gas system. For example, if the pressure relief valve is set for 10 inches of water column, and the manometer in the digester gas line which monitors the pressure in the roof of the digester, shows 5 inches, then the regulator valve will be closed and the service line and waste gas line manometers will read zero. When the digester gas line manometer pressure is greater than the pre-set 10 inches, the regulator valve will open and the waste gas line and service line manometers will then show pressure readings indicating the gas is flowing to this equipment.

Pressure Regulators

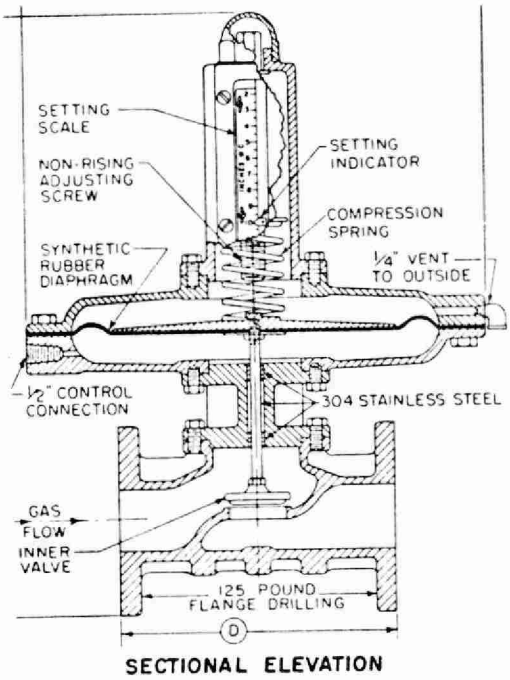
Pressure regulators, Figure 2-11, are placed at various points in the system to regulate the gas pressure to boilers, heaters, compressors and engines. These gas valves are sensitive, diaphragm operated and controlled by a lever with spring. Stop valves should normally be installed in upstream and downstream piping and in the control line to the regulator to allow the unit to be taken off line for maintenance purposes.

Regulators are normally preset to operate at the user's specified setting. If adjustments are required the procedures in the manufacturer's literature should be followed.

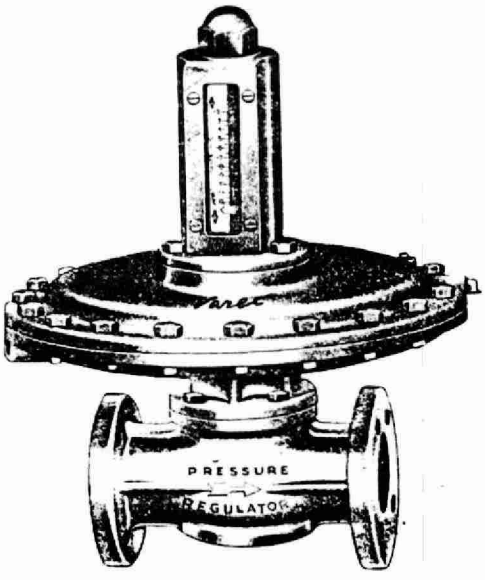
Regulators require very little maintenance. At least annually, lift the cover over the linkage and inspect the parts for easy operation by manually moving the weight arm. During day to day operations, performance of the regulator can be checked by observing the system pressure.



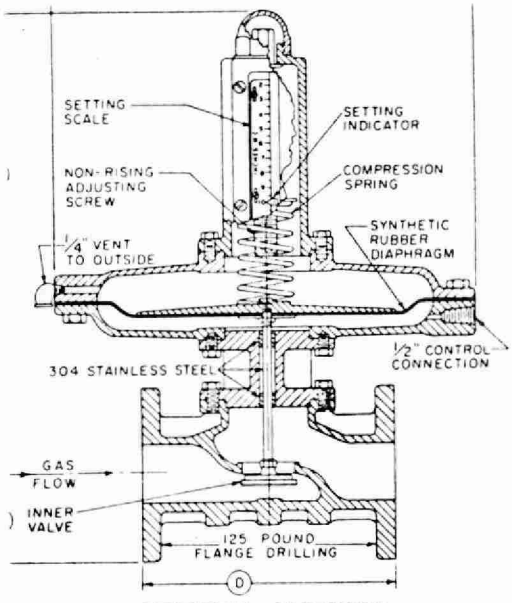
BACK PRESSURE SINGLE PORT FOR
UPSTREAM PRESSURE CONTROL



SECTIONAL ELEVATION



PRESSURE (REDUCING) SINGLE PORT
FOR DOWNSTREAM PRESSURE CONTROL



SECTIONAL ELEVATION

FIGURE 2-11 REGULATORS

Pressure Relief and Flame Trap Assembly

This unit, Figure 2-12, is normally installed in the waste gas burner line to control the plant gas pressure allowing any excess gas to be released to the waste gas burner. The valve is set at the desired pressure, usually 5-9 inches water column, and will continue to release at this pressure. Whenever an adjustment of a pressure setting is made, the proper range of gas system pressure must be checked with a manometer. If the gas pressure in the system is below eight inches of water column, no gas flows to the waste burner. When the gas pressure reaches eight inches of water column, the valve opens slightly, allowing gas to flow to the burner. If the pressure continues to increase, the valve opens further to compensate. The only maintenance this unit requires is on the thermal valve on the discharge side which protects the system from back flashes. This unit is spring loaded and controlled by a fusible element that vents one side of the diaphragm, thus stopping the gas flow when heated. Maintenance includes checking for proper operation of the valve and of the fusible element.

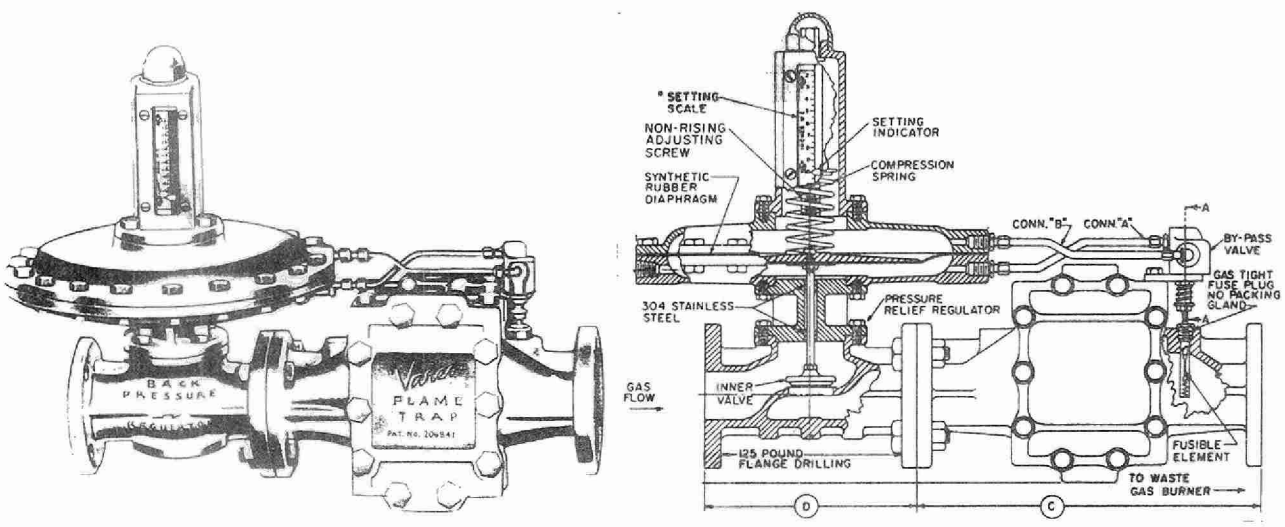


FIGURE 2-12 PRESSURE RELIEF AND FLAME TRAP ASSEMBLY

Flame Checks

Flame checks, Figure 2-13, are used to prevent flashback in small lines carrying inflammable gases. They are

commonly installed in small pilot lines. The flame element consists of compressed wire gauze with free area sufficiently large to provide a minimum pressure drop with maximum fire protection.

The flame check is a union type fitting which permits easy removal of the flame arresting element for inspection and cleaning.

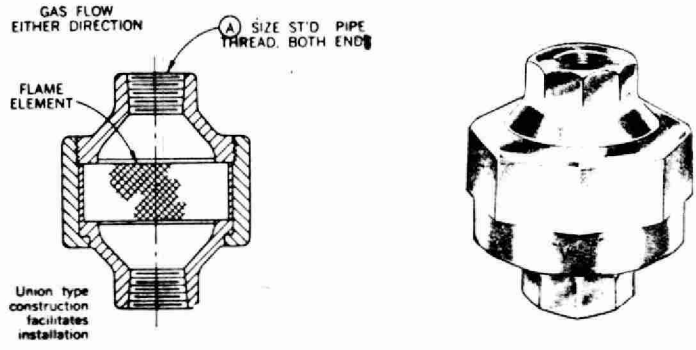


FIGURE 2-13 FLAME CHECKS

Back Pressure Check Valves

These are designed specifically for low pressure gas lines where minimum pressure drop with maximum flow capacity is required. Usually installed downstream of meters, regulators and other gas control devices that might be damaged by an accidental backflow of the gas in the system. See Figure 2-14.

The check valve is of heavy cast aluminum and is equipped with a free swinging pendulum type pallet. The seat ring and pallet are removable. A removable cover is provided for access to the internal parts.

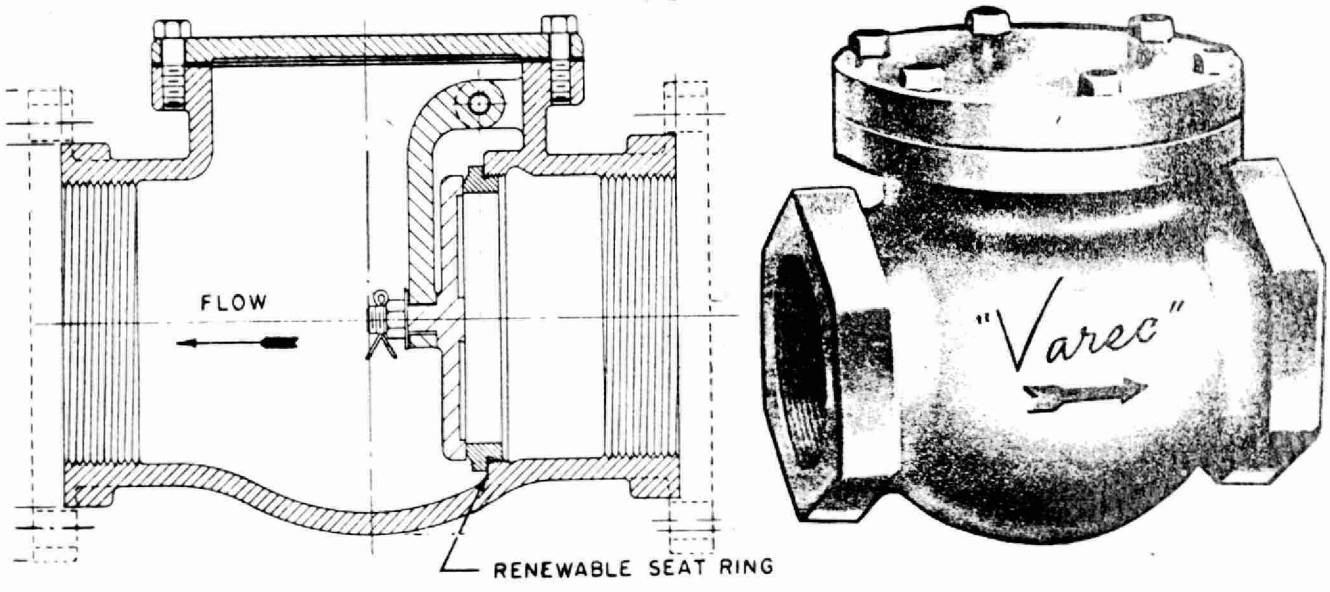


FIGURE 2-14 CHECK VALVE

Explosion Relief Valve

Explosion relief valves, Figure 2-15, are designed to provide emergency excess pressure relief in gas lines leading to waste gas burners, boilers engines, incinerators,storage tanks and low pressure vessels. Flashback explosion pressure is relieved ensuring protection to major equipment in the gas system.

The pallet is dead weight loaded and includes a replaceable synthetic rubber seat insert to ensure gas tight seating. Spring loaded pallets are available to permit higher pressure ranges than available with the dead weight loaded design.

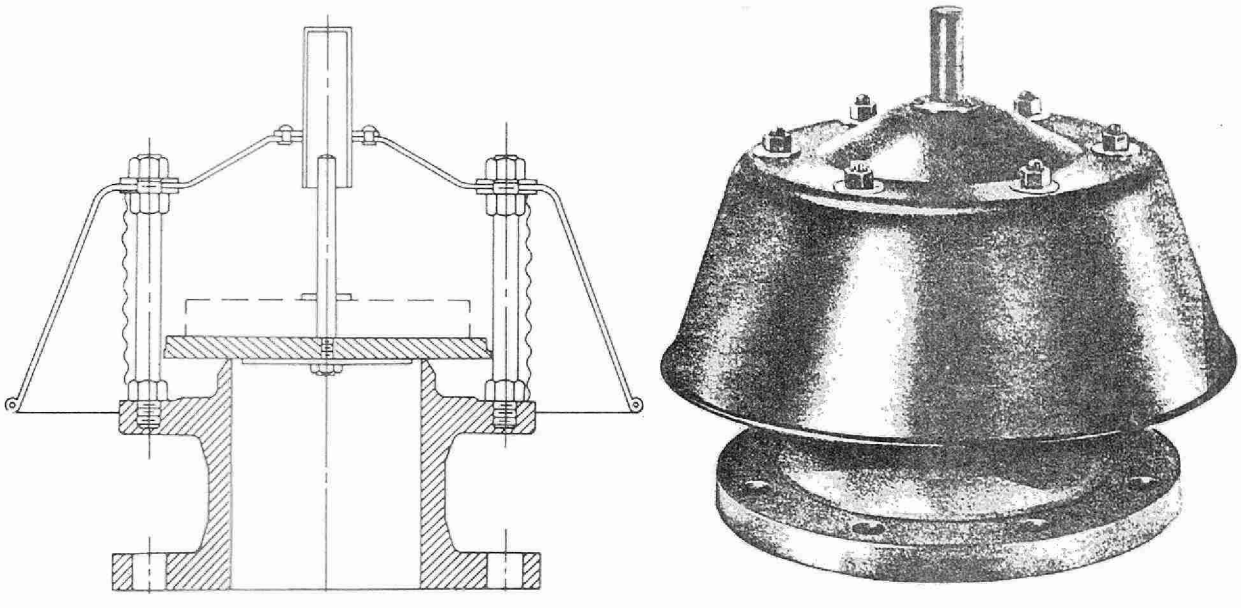


FIGURE 2-15 EXPLOSION RELIEF VALVE

Waste Gas Burner

Waste gas burners are used to burn the excess gas from the digestion system. The waste gas burner is equipped with a continuous burning pilot flame, so that any excess gas passing through the gas regulator will be burned. The pilot flame should be checked daily to be sure that it has not been blown out by wind. If the pilot is out, gas will be vented to the atmosphere creating an odorous and potentially explosive condition. See Figure 2-16.

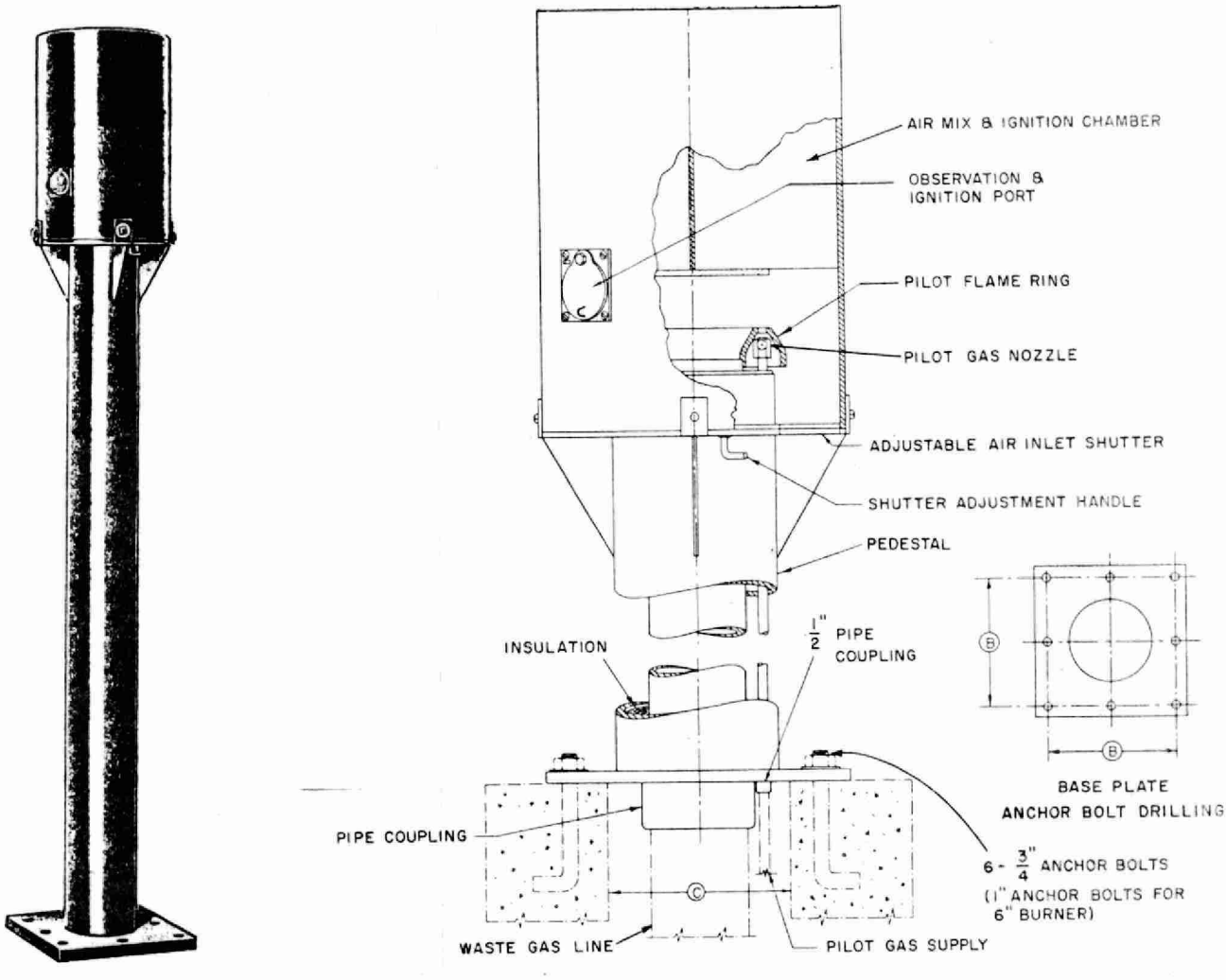


FIGURE 2-16 WASTE GAS BURNER

ADDITIONAL COMPONENTS - HIGH PRESSURE SYSTEMS

A high pressure gas system is used where the low pressure methane is to be compressed and stored for future use and/or required at a higher pressure than that available from the digester, such as utilization in dual fuel engines which drive electrical generators whose requirements are generally in the order of 30 p.s.i. or larger. The system is fed from the low pressure gas train, compressed, and stored in a large gas receiver. This arrangement is generally restricted to the larger sewage plants and is used to drive the high horsepower electric generators during peak power requirement hours to greatly reduce the electric bill.

As with all methane handling equipment, there are a variety of safety devices installed in the piping around the compressor. See Figure 2-17. Should the digester pressure drop to near zero inches W.C. for any reason, the Low Pressure Trip Out switch will trip out the compressor motor before the suction causes the digester vacuum relief valve to open and result in a potentially explosive situation or collapse the dome itself. An operator should, with a little experience, be able to set the compressor timer for maximum gas withdrawal rate while maintaining enough digester pressure to prevent activation of this switch. Installed close to the compressor suction is the strainer to prevent pipe scale or other harmful matter from being drawn into the unit. Between the strainer and compressor, there should be a Vacuum-Pressure gauge to indicate if the screen becomes plugged.

The compressor is usually of the rotary, lobe sliding vein, positive displacement type. The major components are a water cooled cylinder, water cooled heads, and a rotor with non metalic blades inserted in radial slots. The rotor which is smaller than the cylinder bore is supported eccentrically in the bore by the bearings. The crescent shaped pocket is divided into a number of cells by the rotor blades. As the rotor turns, each cell increases to a maximum and then decreases as it completes one revolution. Inlet gas

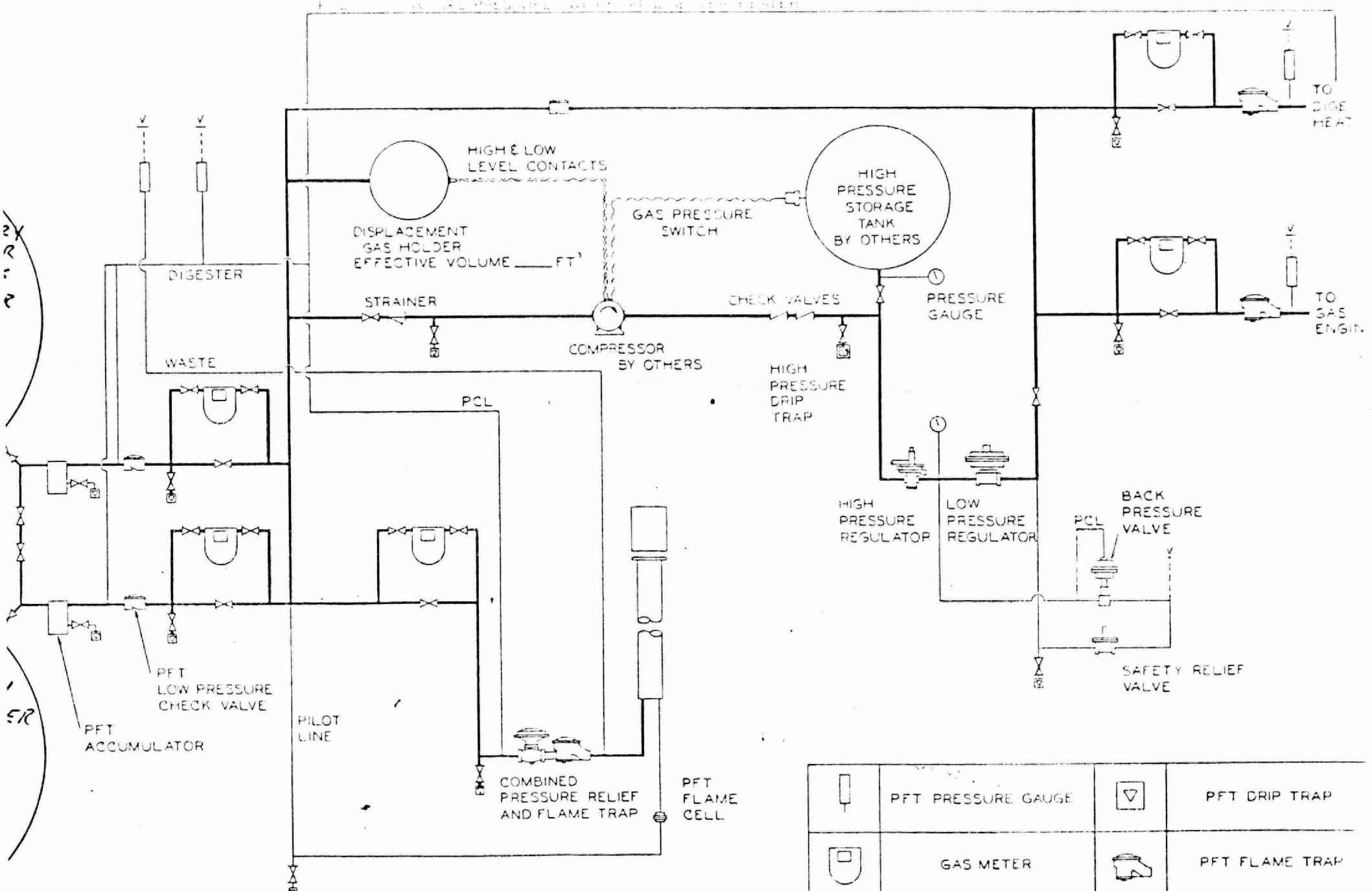


FIGURE 2-17

HIGH PRESSURE SYSTEM

is fed through ports to each cell as the cell increases in size. While the cell is decreasing, gas is being compressed uniformly until it is discharged at the close clearance area. Centrifugal force holds the blades against the cylinder wall as the compression chamber changes size thereby preventing trapped gas from slipping back through the machine.

A check valve should be mounted on the discharge side of the compressor to prevent loss in pressure when the compressor is shut down. The valve also prevents the unit from running backward when the motor is shut off.

The aftercooler cools the discharge gas from the compressor. It is a counterflow heat exchanger where cold water travels through a jacket on the outside of, and through lines installed inside of, the discharge line.

The oil separator removes oil and water droplets from the discharge gas. The separator removes 85-90% when installed with an aftercooler. A high pressure drip trap should be fitted to the separator for removal of collected oil and water.

Between the compressor and high pressure storage receiver is a pressure relief valve properly vented to atmosphere through a flame arrestor. This prevents damage to the compressor due to excessive discharge gas from a closed valve or a restriction in the line. Accompanying this is a high pressure trip out switch which should be set to cut out the compressor motor before the pressure reaches the level required to open the pressure relief valve.

From this point the compressed gas is transferred by steel piping to the storage receiver and high pressure equipment. The receiver generally consists of an above ground steel sphere ranging in design pressure from 30 to 275 P.S.I. and 30-120 feet in diameter.

Pressure relief valves should be mounted on top of the sphere to prevent rupture in the event of thermal expansion. High pressure drip traps should be installed on the low points of the gas transmission system in order to remove any accumulated condensation.

Monitoring devices around the compressor will include:

1. a thermometer to measure the compressor temperature; the cooling water to the compressor should be set to maintain a temperature of 100°F (38°C)

2. a thermometer to measure the discharge gas temperature, which should not exceed 400°F (225°C)

3. a thermometer to measure discharge gas temperature downstream from the aftercooler; the cooling water should be set for about 100°F (38°C)

4. a pressure gauge to monitor the pressure in the gas receiver.

MAINTENANCE

Attached at Appendix C is a maintenance guide for digester gas system components. This is not a substitute for the manuals and instructions provided by a manufacturer.

EXTRACTS

DRAFT CODE

CGA B105

INSTALLATION CODE

FOR

DIGESTER GAS SYSTEMS

4.5 Pressure/Vacuum Relieving and Flame Arresting on Digesters

4.5.1 Pressure/Vacuum relief shall be provided on all digesters and shall be:

a) located on the digester roof and as close as practicable to the digester gas holding space.

b) vented separately

c) vented directly to the outdoors

4.5.2 Digester roof mounted pressure/vacuum relief valves and flame arresters shall be protected and insulated from the elements of the weather to ensure reliability and shall be tested before going into service and at periodic intervals during operation.

4.5.3 No shut-off valve, manual or otherwise, other shut-off device, closure or obstruction of any kind, with the exception of the flame arrester, shall be installed in the gas connection between the digester excess gas pressure/vacuum safety relief valve and the digester gas holding space. Note - This is a listed Prohibited Practice.

4.5.4 Where two pair of flame arrestors and pressure/vacuum relief valves are piped in parallel a three way manual change over valve may be installed in the common supply piping so that there shall be a flame arrestor and pressure/vacuum relief valve in effective service at all times.

4.6 Flame Arresters

4.6.1 Flame arresters shall be provided on all digesters and shall be installed immediately upstream from the pressure/vacuum relief valve.

6 REQUIREMENTS FOR GAS COMPRESSORS AND BOOSTERS

6.1 General

6.1.1 An automatic low gas pressure cut-off switch shall be installed in the gas supply piping upstream of all gas compressors and shall be set to open at an upstream gas pressure not less than 0.5 kPa above atmosphere. (Refer to Part II Schematic Diagrams Figure 29 Series and Figure 37 Series).

6.1.2 An automatic hi gas pressure cut-off switch shall be installed in the gas discharge piping downstream of all gas compressors and shall be set to open at not more than 125% of the normal operating pressure.

6.1.3 Where compressors are used for re-circulating digester gas through the digester for agitation, series 29, 37 and 46 schematics do not apply.

6.1.4 All rooms where gas compressors are installed shall be provided with continuous air circulation of outside air through the room to the outside and the means of circulation shall not consist of doors and windows.

6.1.5 Continuous circulation shall be by means of mechanical ventilation at the minimum rate of 5 air changes per hour.

6.1.6 Where a compressor is used to supply digester gas to a sludge incinerator the schematic diagrams in Part II, Figures?? and ?? to be used.

6.2 Digester Gas Recirculating Low Pressure Compressors

6.2.1 Where compressors are used for recirculating digester gas through the digester for agitation, series 29, 37 and 46 schematics do not apply.

6.2.2 All rooms where gas compressors are installed shall be provided with continuous air circulation of outside air through the room to the outside and the means of circulation shall not consist of doors and windows.

6.2.3 Continuous circulation shall be by means of mechanical ventilation at the minimum rate of 5 air changes per hour.

6.3 Digester Gas Holder Compressors

6.3.1 Where a compressor is used for a digester gas holder the schematic diagrams in Part 11 Figures shall be used.

6.3.2 All rooms where gas compressors are installed shall be provided with continuous air circulation of outside air through the room to the outside and the means of circulation shall not consist of doors and windows.

6.3.3 Continuous circulation shall be by means of mechanical ventilation at the minimum rate of 5 air changes per hour.

6.4 Gas Boosters

6.4.1 Where gas pressure boosters are installed in boiler rooms they shall be of the hermetically sealed type and shall be directly connected to the boiler valve train.

6.5 Non-Hermetically Sealed Gas Compressors Additional Requirements

6.5.1 Where non-hermetically sealed compressors are used they shall be installed in rooms separate from the boiler and shall be isolated from any source of ignition; and;

6.5.2 Dividing walls between rooms containing gas compressors of the non-hermetically sealed type and digester buildings or other parts of digester buildings shall be gas tight; and;

6.5.3 Entry into a room containing a gas compressor of the non-hermetically sealed type shall be only from the outdoors; and;

6.5.4 Supplementary mechanical forced ventilation at the rate of 10 air changes per hour shall be provided for personnel entry. A switch for the supplementary ventilation shall be installed in a readily accessible location just outside the entrance door.

6.6 Digester Gas Storage Containers

6.6.1 Tanks, cylinders, or spheres used for storage of digester gas at pressures above 15 psi shall be approved by the Boiler and Pressure Vessels Inspection Authority of the Province in which they are to be installed, in accordance with CSA Standard B51, Code for the Construction and Inspection of Boilers and Pressure Vessels, and applicable Provincial Regulations covering unfired pressure vessels.

6.6.2 Digester Gas Storage Containers shall be installed so that they can be readily inspected and tested and the installation shall be acceptable to the enforcing authority.

7 MANUAL SHUT-OFF VALVES

7.1 Manual shut-off valves used on digester gas piping shall be of the same size as the pipe used and shall be of the ball or plug type suitable for the application.

7.1.1 Lubricated type valves shall conform to the current Standard CGA 3.11 LEVER OPERATED, PRESSURE LUBRICATED, PLUG TYPE GAS SHUT-OFF VALVES.

7.1.2 Non-lubricated type valves shall conform to the current Standard CGA 3.16 LEVER OPERATED NON-LUBRICATED GAS SHUT-OFF VALVES.

8 DRIP TRAPS

8.1 Drip traps used on digester gas piping systems shall be of the manual mechanically operated type and shall be installed in accessible, well ventilated, easily seen location, at the low points of all systems carrying wet gas.

8.2 They shall be installed so that the open end of the drain pipe extending from the manual drip trap is accessible, easily seen and provides an adequate air gap for condensate collection.

8.3 Each drain pipe connecting to a drip trap shall be fitted with a manual ball or plug type shut-off valve upstream from the union.

8.4 For preferred locations of drip traps, see Series 37 Schematic Drawings.

8.5 Drip traps are not required in systems carrying dry gas other than those indicated in clause 5.8.10.

9 GAS PRESSURE RECORDERS AND INDICATORS

9.1 Digester gas pressure recording and indicating instruments shall be fitted with a manual shut-off valve which shall be located upstream from the union connection in the gas supply pipe to the recorder.

9.2 A vent shall be installed from manometer type pressure indicators.

10 CHECK VALVES AND BACK FLOW PREVENTERS

10.1 Where air, oxygen or other gas under pressure is used in connection with the digester gas supply, back check valves, back flow preventers or other suitable equipment shall be provided as close as practicable to the point of interconnection to prevent the interchange of such gases in the piping or tubing systems.

10.2 Check valves where used shall be acceptable to the enforcing authority.

11 WATER ACCUMULATORS

11.1 Water accumulators shall be equipped with a manual drip trap or have other means of draining which will maintain a reliable gas seal and be acceptable to the enforcing authorities.

11.2 Water accumulators equipped with drip traps shall not be located in non hazardous rooms or areas except when the installation is in accordance with clauses 16.1.1 and 16.1.2.
Note - This is a listed Prohibited Practice.

15 WASTE GAS FLARE STACKS AND WASTE GAS BURNER IGNITION SYSTEMS

15.1 The waste gas flare stack burner shall be a minimum of 4 m above grade or maintenance platform level and the waste gas flare stack shall be at least 1.5 m above any obstruction. The location of the burner ignitor assembly shall be not more than 4 m above grade or maintenance platform level and the burner housing shall have easy access to a covered opening allowing a readily accessible means for servicing and maintenance of the ignition assembly.

15.1.1 Unburned digester gas shall not be exhausted to the atmosphere from the flare stacks.
Note - This is a Prohibited Practice.

15.1.2 The waste gas burner and igniter shall be not less than 15 m measured linearly outward from the perimeter of the digester or other source of combustible gas.*

15.1.3 Waste Gas Flare Stacks may be located so that their termination is not less than 7.5 m from any other Waste Gas Flare Stack termination or any Boiler Vent Stack termination.

* Note: Such as bleeds or vents, reliefs from valves, regulators, other controls, incinerators or sludge overlow boxes.

20 GAS PRESSURE REGULATORS

20.1 Gas pressure regulators shall be of the spring loaded, dead-weight, or pressure-balanced type. Springs or weights shall be covered by a housing.

CALCULATION

WEIGHT REQUIREMENTS

PRESSURE/VACUUM RELIEF VALVES

1. FORMULA

Weights Required = $\pi R^2 P$

Where π = 3.1416

R = Radius of valve diameter

P = Pressure in PSIG

2. DIGESTER DATA

Diameter 100 ft. R = 50 ft. (600")

Operating Pressure: 14" W.C. or 0.5 PSIG

Total Roof Pressure is:

3.1416 x 600" x 600" x .5 = 565488 lbs or 282.7 tons

At 21" W.C. this becomes:

3.1416 x 600 x 600 x .75 = 848232 lbs or 424.1 tons

3. EXAMPLES

a) Diameter Valve = 5" R = 2.5"

Say Gas Pressure 14" W.C. or 0.5 PSIG

Total Valve Area = 3.1416 x 2.5 x 2.5 x 0.5 = 9.8 lbs

Therefore lead weights required = 9.8 lbs

b) Diameter valve = 3" R = 1.5"

Gas pressure 14" W.C. or 0.5 PSIG

Total Valve area pressure = 3.1416 x 1.5 x 1.5 x 0.5

= 3.53 lbs

Therefore lead weights required = 3.53 lbs.

DIGESTER GAS DISTRIBUTION SYSTEM

MAINTENANCE GUIDE

	ITEM	FUNCTION	MAINTENANCE FREQUENCY	MAINTENANCE FUNCTIONS
1.	Pressure Relief Valves	Vents excess gas to atmosphere	3 monthly yearly	Inspect for proper operation. Dismantle check valve for free operation and corrosion. Clean, repair as necessary, adjust weights (if necessary) and reassemble
2.	Vacuum Relief Valve	Relieves negative pressure to prevent collapse of tank or allowing entry of air to digester	3 monthly yearly	As for Pressure Relief Valve As for Pressure Relief Valve
3.	Flame Arrestors	Protects against flash-back	3 monthly	Shut off the flow of gas. Valve gas off. Pull one end plate and slide baffle cartridge and replace with spare Dean unit. Clean any build up of scale from plates. DO NOT DISMANTLE CORE. Test for leaks after reassembling.
4.	Thermal Valves	Shuts off gas if flame develops and heat sufficient to melt fusible plug	Based on experience. yearly	Remove wing nut. Visually inspect stem position through glass tube. If stem not visible, remove valve. Replace metal slug. Reassemble. Dismantle. Inspect and clean by removing any residue and scale. Reassemble

DIGESTER GAS DISTRIBUTION SYSTEM

MAINTENANCE GUIDE

	ITEM	FUNCTION	MAINTENANCE FREQUENCY	MAINTENANCE FUNCTIONS
5.	Sediment Traps	Removes scale and moisture from gas to protect relatively complex equipment.	As experience dictates.	Remove cover plate. Check level using inspection pipe. Clean using blowout connection
6.	Drip Traps	Installed at all low points to collect and safely remove condensed water in gas system.	Twice daily	Drain. May require draining more often in cold weather
			6 monthly	Dismantle. Inspect. Clean as necessary.
7.	Manometers	To monitor/check gas pressure in lines leading from digester and to utilities and waste burner		
8.	Pressure Regulator	To control release of gas at a predetermined pressure.	Annually	Lift cover over linkage; inspect parts for ease of operation by manually moving the weight arm. Check diaphragm for deterioration
9.	Pressure Relief and Flame Trap assembly	To maintain a set back pressure so that only surplus gas is wasted and to stop flame and explosion waves	3 monthly Annually	See Flame Arrestor and Pressure Relief Valve

DIGESTER GAS DISTRIBUTION SYSTEM

MAINTENANCE GUIDE

ITEM	FUNCTION	MAINTENANCE	
		FREQUENCY	FUNCTIONS
10. Flame Checks	To prevent flashback in small lines	As Experience Dictates	Remove, inspect and clean flame arresting element.
11. Back Pressure Check Valves	To prevent backflow of gas; Usually installed downstream of meters	Annually	Remove cover. Check valve for free movement and corrosion.
12. Explosion Relief	To protect major equipment by providing emergency excess pressure relief.		
13. Waste Gas Burner (incl. Pilot)	To burn off excess gas	Annually	Inspect. Check ring type pilot daily. Replace electrodes (if installed) as necessary.
14. Manual gas cocks and valves	Various	As experience dictates. Annually	Operate to check for ease of operation. Dismantle, clean, lubricate.

DIGESTER GAS DISTRIBUTION SYSTEM

MAINTENANCE GUIDE

	ITEM	FUNCTION	MAINTENANCE FREQUENCY	MAINTENANCE FUNCTIONS
15.	Gas Booster and Compressors		Annually	Dismantle. Clean, lubricate and repack gland (if applicable).
16.	Heat Exchanger			
17.	Gas Piping (Above ground)	To transmit gas	Annually or As Experience Dictates	Check by removing inspection spools for corrosion, accummulation of deposits. Check joints for leaks using soap test. Repaint as necessary.
18.	Underground Piping	To transmit gas	Every three years	Pressure test.
19.	Vent Lines		Annually	Check to ensure no obstructions.
20.	Vent Fans	To prevent build up of hazardous concentration of gas	Annually	Inspect, lubricate.

SUBJECT:

DIGESTER GAS DISTRIBUTION

TOPIC: 3

DIGESTER GAS CHARACTERISTICS AND PIPING SYSTEMS

OBJECTIVES:

The trainee will be able to:-

1. Name and apply the code(s) to which digester gas installations must conform.
2. Recall the important characteristics of Digester Gas including:
   a) Composition
   b) UEL and LEL
   c) Heating Value
3. Name the identification requirements for digester gas piping.
4. Recall the materials acceptable for digester gas piping.
5. Recall the materials acceptable for venting.
6. Recall the restrictions on the use of plastic pipe.
7. Recall:
   a) the purpose of inspection points and purge points,
   b) the proper location and size of inspection spools and purge points,
   c) the type(s) of valves used to isolate inspection spools,
   d) the agents used for purging and
   e) purging pressure.
8. Recall pressure testing requirements for:
   a) New underground piping.
   b) Piping inside buildings and connecting pipeways.
9. Recall the protection requirements for gas piping passing through walls and partitions.
10. Recall the installation requirements for gas piping installed underground.

DIGESTER GAS CHARACTERISTICS AND PIPING SYSTEMS

GENERAL

New digester gas installations must conform to the requirements of the Installation Code (CGA B 149-1-1976) for Natural Gas, to be replaced by Code (CGA B 105) Digester Gas Distribution System, presently in draft. Existing installations fail, in many cases, to meet these standards since, at the time of construction, standards were less stringent or not enforced. It is essential, therefore, that maintenance and repair be undertaken with the most recent codes as the basis of work so that installations are gradually upgraded and a safe working environment is provided for the operator.

This topic which includes extracts of the codes mentioned above, attached as Appendices A and B, deals with gas piping systems. Topic 4 deals with other fuels (Natural Gas, Propane and Fuel Oil) common to WPCPs.

Digester Gas Characteristics

Gas produced by anaerobic digestion has a high percentage of Methane, its main constituent. Its composition will vary from 60% to 75% Methane, 20% to 40% Carbon dioxide and varying percentages of oxygen, nitrogen and hydrogen sulphide. It has a heating value of 500-800 BTU per cubic foot; it is flammable toxic and corrosive. Digester gas is explosive when mixed with air in a certain ratio. If the air to gas mixture is 5.7% to 13.5% by volume, it will explode if brought into contact with an open flame or spark. Below the Lower Explosive Limit (LEL) of 5.7%, nothing will occur while above the Upper Explosive Limit (UEL) 13.5%, the mixture burns but will not explode. Therefore, after every start-up of the digester, it must be made certain that the air to gas ratio (mixture) in the digester dome and piping system is below 5 per cent. Until this concentration is reached the gas should be vented to atmosphere. This includes the gas lines serving the plant boiler and the waste gas burner.

By the nature of its production digester gas is a very wet gas. For the purposes of the applicable Installation Codes, digester gas is considered dry if its dewpoint is $2^{\circ}C$ below the lowest temperature to which it will be exposed in any part of the system.

GAS PIPING IDENTIFICATION

It is essential that, in a facility, where various liquids, gases and/or slurries are being conveyed from one location to another, some means of identification is available. The most popular method is a combination of colour code and descriptive information. Special markings may also be required to warn of direction of flow, type of fluid within the pipe or other dangerous conditions.

Wastewater treatment plant digestion gas piping must be painted or colour coded with high visibility yellow orange paint. Each gas type system of piping must be labeled every 3 meters with the name of the gas being conducted and the direction of flow. Plastic piping systems must also be marked every three meters with the maximum rated operating temperature of the plastic material. All piping and fittings must carry a permanent manufacturer's identification as to material.

MATERIALS PIPING AND FITTINGS

The approved piping and fittings, depending on the application are:

1. Carbon (Black) Steel

2. Ductile Iron
3. Alloy
4. Stainless Steel
5. Plastic
6. Copper Pipe. For Vent or Bleed Lines Only. Type K not less than 3/8"ID with flared or compression type fittings.
7. Black Iron Pipe. For Vent or Bleed Lines 3/8"IPS Schedule 40.

All gasketing materials and seals shall be of neoprene or such other material resistant to the action of gas. Designers and owners are warned that some of the material may not have a life expectancy applicable to the design use. Thus caution must be exercised in the interest of safety when selecting and specifying material to be utilized.

Digester gas piping shall take the most direct route, contain as few elbows, drops and risers as is practicable, be of sufficient size to accomodate the maximum load requirements and when installed shall be at least equal to the applicable requirements of Appendix A CGA B 149.1 INSTALLATION CODE FOR NATURAL GAS BURNING APPLIANCES AND EQUIPMENT corrected to the appropriate calorific value and relative density. For isolation and purging purposes, every run of digester gas pipe shall have a manual plug or ball type shut-off valve, approved for the application, installed at either end and at any junction.

Components and accessories used in the system and made of cast iron or cast aluminum are acceptable. Cast iron pipe and fittings including flanges, but excluding ductile iron, shall not be used.

The following paragraphs state certain provisions applicable to specific materials.

Carbon Steel Pipes and Fittings

Carbon steel pipe conforming to the standard ANSI B 36.10 and fabricated to the specifications for welded and seamless pipe, or equivalent may be used if acceptable to the enforcing authorities.

Pipe thickness must conform to the requirements of CGA B 149.1 Code, Section 10. Carbon steel pipe must not be used for underground buried installations. Pipe joints may be threaded flanged or welded but, for pipe over 65 mm(2 1/2") screwed joints must not be used.

The following lines of fittings must be used with standard weight carbon steel pipe

1. Class 150 or Class 130 Malleable iron threaded fittings to ANSI B 16.3 Standard
2. Carbon steel welded fittings to ANSI B 16.9 Standard and ASTMA 234 Specification
3. Forged steel flanges, Class 150, or welded fittings to ASTM Specification B 88 and having an internal cross-sectional area of not less than 80 square millimetres.

It should be noted that, with wet gas, steel pipe under 100 mm (4") diameter size deteriorates rapidly. When digester gas has been properly dried steel pipe may be used more extensively and with better life expectancy.

Ductile Iron Piping and Fittings

Ductile iron piping and fittings must conform to certain standards: -

1. Ductile iron pipe, centrifugally cast in metal molds or sand lined molds to CSA B131.14
2. Flanged ductile iron pipe to CSA B131.17 Flanged Cast Iron and Ductile Iron Pipe with Threaded Flanges.
3. Ductile iron fittings, 4 inches through 24 inches to CSA B131.15 Gray Iron and Ductile Iron Fittings 3 inches through 24 inches.

When ductile iron is used: -

1. Above ground pipe joints shall be flanged Class 125 to ANSI B16.1 and ASTM A-47 Standards. Threaded flanges are acceptable.
2. Underground (buried) pipe joints shall be made with ductile iron mechanical compression type joints with neoprene gaskets to CSA B131.10 (ANSI A 21.11) where acceptable to the enforcing authorities.

Plastic Piping and Fittings

Plastic piping and fittings where used must be certified by the CSA, CGA or ULC to CSA standard 137.4 as a polyethylene plastic piping system. Joining of plastic pipe must conform to CSA standard 2184 Gas Pipeline Systems. This is to ensure that it is acceptable for gas supply piping and that the method of joining is by thermal fusion or by an equally acceptable means using the proper tools and qualified personnel. Mechanical compression type flexible or non flexible joining methods and fillings are acceptable only for underground application with the acceptance of the enforcing authority.

To prevent pipe failure or fatigue, plastic pipe -

1. Must NOT be installed to convey compressor gas just downstream from the gas compressor. Excess gas temperature may result in pipe failure through pipe fatigue.
2. Must NOT be subjected to internal or external temperatures in excess of its certified range and in no case more than 100°F. (38°C)
3. Must be effectively shielded in outdoor locations from the sun's rays if it is subject to adverse affects by the rays.

Plastic pipe must be installed and supported to maintain a uniform designed slope and when installed shall provide for expansion and contraction as specified by the manufacturer.

Alloy Piping and Fittings.

Alloy piping may be used only where acceptable to the enforcing authority. When used it shall have a thickness not less than standard weight and will conform to the specification ASTM A 714 High Strength Low Alloy Welded and Stainless Steel Pipe.

Fittings used with alloy steel pipe shall be Class 150 (standard weight) malleable iron threaded fittings conforming to ANSI B 16.3 Code.

Stainless Steel Piping and Fittings.

Type 316 Stainless Steel Pipe and Fittings may be used for above ground and underground installations only where acceptable to the enforcing authority. Appendix B describes the detailed requirements for above ground installation. For underground installations stainless steel pipe in sizes 12.7 to 304.8 mm (½" to 12½) must be of schedule 405 in accordance with ANSI B 36.19. The fillings must also be Schedule 405 butt-welded type in accordance with MSS SP 43 and ANSI B 16.9.

INSPECTION POINTS

To permit periodic internal inspection of the piping system, at least one inspection spool of the same material as the pipe, not less than 300 mm (12") in length, shall be provided at an appropriate, readily accessible, low point in a horizontal run of the system carrying wet gas. A similar spool shall be provided in a run carrying dry gas. Other inspection points may be provided with tee's (blank flange) or elbows. Manual plug or ball type valves are to allow isolation and removal of the spool and to permit internal inspection of the pipe upstream and downstream of the spool. Large plants with extensive piping systems and extensions to existing systems will require additional inspection spools in recognizable problem areas.

PURGING

To permit purging the whole or part of the system, purge points shall be provided in the piping at each branch system manual shut-off valve, at both sides of the valve, if applicable, and at other necessary points in the system. The purge points shall be not less than 1/2" nominal pipe size, fitted with a manual plug or ball type shut-off valve, which shall be plugged or capped.

Purge points shall be located so as to avoid deposition of sediment.

Digester gas piping before being put into service shall be purged of air and before being removed for inspection

repair or replacement shall be purged of digester gas. Purging shall be done using only carbon dioxide or nitrogen gas to not more than the maximum positive pressure setting of the waste gas burner excess pressure relief valve but shall not be in excess of 20 kPa, whichever is lesser. Underground digester gas piping may be purged hydrostatically instead of using carbon dioxide or nitrogen. All other purging procedures shall be carried out as outlined in CGA B149.1 INSTALLATION CODE FOR NATURAL GAS BURNING APPLIANCES AND EQUIPMENT. (The American Gas Association Publication AGA PURGING PRACTICES AND PROCEDURES is also recommended as good practice).

PRESSURE TESTING PIPING

New underground piping shall be hydrostatically tested before back-filling to 700 kPa for a duration of one hour with zero leakage. All new piping in the gas system located inside buildings and connecting pipeways shall be pressure tested with air or inert gas to 1-1/2 times rated working positive pressure or 20 kPa, whichever is the greater for a minimum of 1 hour and a soap solution used for leak detection.

GAS PIPING PASSING THROUGH WALLS AND PARTITIONS

When gas piping passes through walls or partitions, it shall be protected from direct contact with the wall or partition construction material, and the wrapper or coating shall not restrain longitudinal movement of the pipe.

1. Inside Walls and Partitions.

   Where a metal sleeve is used to protect gas piping passing through an inside wall or partition the metal used shall be of a material resistant to corrosive action from the construction material used in the wall or partition, or the outside surface of the metal sleeve shall be coated or wrapped with a corrosion resistant material.

2. Outside Walls. Where a metal sleeve is used to protect gas piping through an outside wall the metal used shall be of a material resistant to corrosive action from the construction material used in the wall, or the outside surface of the sleeve shall be coated or wrapped with a corrosion resistant material and the remaining space between the outside surface of the sleeve shall be caulked with a corrosion resistant caulking material to provide a water seal.

UNDERGROUND PIPING

Underground piping (other than plastic) shall be wrapped or coated with an asphaltic compound or equivalent corrosion protection. It will be installed -

1. below frost level
2. with a minimum of 150 mm of tamped sand all around before backfilling
3. without threaded fittings.

When piping is laid or intended to be under hardtop, pavement, or roadway for its entire length or when the hardtop or pavement extends for 7.5 m or more of its length the pipe shall be placed in a casing of not less than 50 mm larger internal diameter. The casing material shall have a smooth interior to prevent damage to the gas pipe and shall be acceptable to the enforcing authorities.

The casing shall be sealed at each end and a vent pipe of not less than 2 inch nominal pipe size shall be installed at each end extending above the ground and shall be constructed so as to prevent water from entering the casing. The termination of each vent shall be not less than 600 mm above grade level, shall be provided with an 180° bend with bug screen, or equivalent and shall be protected against physical damage.

Short lengths of underground piping shall have a 2% slope with the low end located in the building at which there shall be installed a manual drip trap. Long lengths of underground piping, where it is not practical to have one

continuous slope,may be installed with the required slope in two or more directions from a common high point, if a manual drip trap is located inside the building(s) at each low point.

CGA
B149.1-1976

EXTRACTS FROM
INSTALLATION CODE
FOR
NATURAL GAS
APPLIANCES AND EQUIPMENT

10. PIPING AND TUBING SYSTEMS, HOSE AND FITTINGS

10.1 General

10.1.2 Piping, tubing and fittings shall be new, or used provided they have not been used for any other purpose than for conveying propane or gas, and shall meet the requirements of Clause 10.1.3.

10.1.3 Piping, tubing and fittings if removed from any gas installation, shall not be used again until they have been thoroughly cleaned, inspected and ascertained to be equivalent to new material.

10.2 Material

10.2.1 Steel piping shall be black and shall comply with CSA Standard B63, Welded and Seamless Steel Pipe.

10.2.2 Fittings used with steel pipe shall be of malleable iron or steel and shall comply with ANSI Standard B 16.3 for Malleable Iron Fittings.

10.3.2 Piping and Tubing Systems Operating at Pressures 1/2 psig or Less.

10.3.2.1 Piping and tubing systems operating at pressures 1/2 psig or less shall be designed so that the loss in pressure between last stage regulators and appliances shall not exceed 0.5 in w.c. The minimum size of pipe, tubing and fittings shall be in accordance with Appendix B.

10.3.3 Piping and Tubing Systems Operating at Pressures in Excess of 1/2 psig

10.3.3.1 Piping and tubing systems operating at pressures in excess of 1/2 psig:- the pressure loss in piping and tubing systems operating at pressures in excess of 1/2 psig from the last stage regulators to utilization equipment under maximum flow shall not exceed 10% and shall be in accordance with Appendix B.

10.3.5 Resistance of Bends, Fittings and Valves

10.3.5.1 Appendix B gives the resistance of bends, fittings and valves as equivalent length of straight pipe in ft to be added to the actual length to obtain the total equivalent length on which pressure loss calculations shall be based.

10.3.6 Piping less than 1/2 in diameter shall not be used indoors except that 3/8 in piping may be used as a branch line not exceeding 25 ft in length and not supplying more than 15,000 Btuh.

10.3.7 Piping less than 1/2 in diameter shall not be used in any concealed location.

10.3.8 Steel piping of less than 1/2 in diameter shall not be used underground.

10.3.9 The minimum size of piping from the point of distributor supply to the drop or riser of any central heating appliance, unit heater or similar heating appliance of input of 76,000 Btuh or more shall be 1 in diameter and the drop or riser shall be not less than 3/4 in diameter

TABLE 10.6.1

Gas Supply Pressure

Type of Building	Maximum pressure, psig	
	Other than Central Machine Room	Central Machine Room
One & two family dwellings	½	–
Hotels & Motels	5	20
[illegible]	5	20
[illegible]	5	20
[illegible]	20	20*
[illegible]	60	60
[illegible]		60

*Not permissible in occupiable stories, rooms located on the roof of commercial buildings

10.8 Location

10.8.2 Piping or tubing shall not be installed:

a) in stairwells of other than one or two family dwellings;

b) in chimneys, flues, elevator shafts, dumbwaiters, coal chutes, clothes chutes and garbage chutes;

c) in heating or ventilating plenums, ducts and shafts; or

d) in contact with cinders or ashes.

10.8.6 Vertical piping chases shall have an escape opening at the top of each chase and the opening shall have a munimum area equivalent to a round opening of 1 in diameter.

10.9 Piping Practices

10.9.1 Piping and fittings shall be clear and free from cutting or threading burrs, scale, and defects.

10.9.2 The ends of all piping shall be reamed.

10.9.3 Piping or tubing shall not be supported by any other piping or tubing but shall be installed with individual supports of sufficient strength and quality. Piping supports shall be spaced in accordance with Table 10.9.3

TABLE 10.9.3

Spacing of Supports for Piping

IPS	Maximum Spacing of Supports – ft
⅛ or less – horizontal	6
¼-1 – horizontal	8
1¼-2½ – horizontal	10
3-4 – horizontal	15
5-8 – horizontal	20
10 or larger – horizontal	25
1¼ or larger – vertical	Every floor but not less than 125% of horizontal spacings

10.10 Joints and Connections

10.10.2 Piping 2 1/2 in diameter and over, shall have welded joints except threaded joints may be used if in the opinion of the enforcing authority, welded joints are not practicable.

TABLE 10.10.3

Approximate Length of Pipe Threads

IPS	Approximate Length of Threaded Portion (Inches)
½	¾
¾	¾
1	⅞
1¼	1
1½	1
2	1
2½	1½
3	1½
4	1⅝

10.10.5 Gasket materials shall be of neoprene or other inert material resistant to the action of gas. Natural rubber shall not be used.

10.11 Branch Outlet Piping

10.11.2 Branch outlet piping shall be taken from the top or sides of horizontal piping unless the branch piping is a drop and is provided with a dirt pocket.

10.12 Piping Outlets

10.12.1 Outlets from piping systems shall be securely closed and made tight, during periods when appliances are not connected, by means of:

a) nipples and caps or threaded metal plugs when the pressure is not in excess of 1/2 psig, or

b) shut-off valves which shall be securely closed and made gas tight with nipples and caps or threaded metal plugs, when the pressure is 1/2 psig or over.

10.12.2 Unthreaded portions of piping outlets shall extend at least 1 in through finished ceilings and walls, and at least 2 in through floors.

10.13 Drip and Dirt Pockets

10.13.1 A dirt pocket shall be provided at the bottom of any piping drops serving appliances.

10.13.2 A drip or dirt pocket shall be of such size that:

a) the depth of the drip or dirt pocket is not less than the internal diameter of the piping it serves whichever is the greater; and

b) its diameter is not less than the diameter of the piping it serves.

10.13.4 Every drip or dirt pocket shall be capped.

10.14 Prohibited Practices

10.14.2 Bushing shall not be used.

10.15 Underground Piping and Tubing

10.15.1 Piping having a nominal diameter of less than 1/2 in shall not be used underground.

10.15.2 Underground piping and tubing shall not be installed with threaded fittings, or flare connections.

10.15.6 Underground piping and tubing shall not pass below foundations, walls, or under buildings.

10.17 Identification of Piping

10.17.1 Piping in every institutional, commercial and industrial building shall be painted or banded with at least 1 coat of high visibility yellow-orange paint or tape.

10.18 Manual Shut-Off Valves

10.18.2 A readily accessible manual shut-off valve shall be installed as close as possible to the valve train of each appliance. Where there is a drop or riser to the appliance this valve shall be in the drop or riser.

10.22 Testing of Piping. Tubing, Hose and Fittings

10.22.1 When any part of the system is to be enclosed or concealed, the test specified in Clause 10.22.4 shall precede the work of closing in.

10.22.2 Before turning on the gas a check shall be made to ensure that all openings from which gas may escape are closed.

10.22.3 Immediately after turning the gas into the piping or tubing a test shall be made to determine that no gas is escaping by carefully watching the test dial of the meter or where a meter is not provided, by listening for gas flow through the regulator.

10.22.4 Pressure Testing. All piping and tubing shall be pressure tested using either gas, air or an inert gas (carbon dioxide, nitrogen or a mixture of these) in accordance with the following:

a) Before appliances are connected, piping or tubing shall be tested in accordance with:;

TABLE 10.22.4(a)

Test Pressure Table

Working Pressure (PSIG)	Diameter of pipe or tubing (inches)	Length of pipe or tubing (ft)	Test Pressure (PSIG)	Test Duration (Hrs)
Less than ½	Less than 1½	100 or less	25	½
Less than ½	All sizes	More than 100	25	1½
½ to 33	All sizes	All lengths	50	24
Over 33	All sizes	All lengths	1½ times the max. operating pressure	24
All piping in false ceilings and concealed spaces			The greater of 3 psig or 1½ times the max. operating pressure	24

b) after appliances are connected, the piping or tubing shall retain a test pressure of not less than 10 munutes without showing any drop in pressure. Pressure shall be measured with a pressure gauge or an equivalent device so calibrated as to be read in increments of not greater than 1 in w.c. The source of the test pressure shall be isolated before readings are commenced and if a leak is indicated by the test, the source of the leak shall be located by the use of an approved liquid leak detector solution or device.

10.22.5 Appliance connections and valve trains shall be checked while under normal operating pressure with an approved liquid leak detector solution or other approved device after the appliances are connected.

10.23 Purging of Piping and Tubing Systems and Hose After Leak Testing

10.23.1 Piping and tubing systems and hose containing air or inert gas shall be purged:

a) to the outdoors as in Clause 10.23.3 or

b) to an approved purge burner

c) and if the piping is 4 in IPS or larger and if air has been used for testing, the piping must be first purged with carbon dioxide or nitrogen or a mixture of these and the purged with gas in accordance with Clause 10.23.3

d) and the person doing the purging shall be in direct control of the gas during the purging operation by means of a valve having an attached operating handle.

e) and the piping for the purging gas shall be of a size or be reduced to a size not larger than 1/2 in IPS

10.23.3 Purging to Outdoors

10.23.3.1 When piping or tubing systems are to be purged to the outdoors:

a) the purging line shall not terminate closer than 10 ft to any building or air intake; and

b) the purging point shall be under constant supervision from a competent person who shall control the purge by a ¼ turn lever handle valve within 5 ft of the purge point. Such valve shall have an attached operating handle. No other valve shall be used to control or terminate the purge;

c) when purging is being done, smoking shall not be permitted, and maximum precautions shall be taken to remove or shut-off all sources and potential sources of ignition.

10.24 Purging Other Than Than Done After Leak Testing

10.24.1 When purging gas from piping or tubing systems for the purpose of repair, alteration, or abandonment, carbon dioxide, nitrogen or a mixture of these shall be used and the applicable procedures in Section 10.23 shall apply.

TABLE B-1

Maximum Capacity of Schedule 40 Pipe Including Fittings in Cubic Feet Per Hour Based on a Pressure Drop of 0.3 inch Water Column and Specific Gravity of 0.6

Length of Pipe Feet	Nominal Iron Pipe Size (IPS) Inches											
	½	¾	1	1¼	1½	2	2½	3	4	5	6	8
10	93	210	422	930	1,442	2,917	4,775	8,135	17,060	29,970	47,440	96,630
20	66	149	298	657	1,019	2,063	3,376	5,752	12,070	21,190	33,550	68,330
30	54	121	244	537	832	1,684	2,757	4,696	9,851	17,300	27,390	55,790
40	46	105	211	465	721	1,459	2,387	4,067	8,532	14,980	23,720	48,310
50	42	94	189	416	645	1,305	2,135	3,638	7,631	13,400	21,220	43,210
60	38	86	172	379	588	1,191	1,949	3,321	6,966	12,230	19,370	39,450
70	35	79	159	351	545	1,103	1,805	3,074	6,449	11,330	17,930	36,520
80	33	74	149	329	510	1,031	1,688	2,876	6,033	10,590	16,770	34,160
90	31	70	141	310	480	972	1,592	2,711	5,688	9,989	15,810	32,210
100		67	133	294	456	923	1,510	2,572	5,396	9,476	15,000	30,560
125		59	119	263	408	825	1,350	2,301	4,826	8,476	13,420	27,330
150		54	109	240	372	753	1,233	2,100	4,406	7,736	12,250	24,940
175		50	101	222	345	697	1,141	1,944	4,079	7,163	11,340	23,100
200		47	94	208	322	652	1,068	1,819	3,815	6,702	10,610	21,610
250		42	84	186	288	583	955	1,627	3,413	5,994	9,489	19,330
300		38	77	170	263	533	872	1,485	3,115	5,471	8,662	17,640
350		36	71	157	244	493	807	1,375	2,884	5,065	8,018	16,330
400		33	67	147	228	461	755	1,286	2,698	4,738	7,501	15,280
450		31	63	139	215	435	712	1,213	2,544	4,468	7,073	14,410
500			60	131	204	413	675	1,150	2,413	4,238	6,709	13,660
550			57	125	194	393	644	1,097	2,301	4,041	6,397	13,030
600			54	120	186	377	616	1,050	2,203	3,870	6,126	12,480

TABLE B-2

Maximum Capacity of Schedule 40 Pipe Including Fittings in Cubic Feet Per Hour Based on a Pressure Drop of 0.5 inch Water Column and Specific Gravity of 0.6

Length of Pipe Feet	Nominal Iron Pipe Size (IPS) Inches											
	½	¾	1	1¼	1½	2	2½	3	4	5	6	8
10	127	277	535	1,201	1,842	3,696	6,165	10,500	22,020	38,690	61,240	124,700
20	89	196	378	849	1,302	2,613	4,358	7,426	15,580	27,360	43,310	88,210
30	73	159	309	693	1,064	2,134	3,561	6,068	12,730	22,330	35,360	72,020
40	63	138	268	600	921	1,848	3,082	5,252	11,010	19,340	30,620	62,370
50	56	123	239	537	823	1,652	2,756	4,697	9,852	17,300	27,390	55,780
60	51	112	218	488	749	1,503	2,508	4,273	8,963	15,740	24,920	50,760
70	47	103	200	450	690	1,384	2,309	3,935	8,253	14,490	22,950	46,740
80	44	96	187	419	643	1,290	2,152	3,668	7,693	13,510	21,390	43,570
90	42	91	176	395	606	1,215	2,027	3,455	7,246	12,730	20,160	41,060
100	39	86	167	375	575	1,154	1,925	3,280	6,879	12,080	19,130	38,960
125	35	77	150	336	515	1,033	1,723	2,936	6,157	10,810	17,120	34,870
150	32	70	137	307	470	943	1,573	2,681	5,621	9,872	15,630	31,830
175	29	65	127	285	436	874	1,458	2,484	5,208	9,146	14,480	29,490
200	27	61	119	267	409	820	1,368	2,331	4,888	8,585	13,590	27,680
250	24	55	107	240	367	736	1,228	2,092	4,387	7,704	12,200	24,850
300	22	50	98	219	336	673	1,122	1,912	4,009	7,040	11,150	22,700
350	20	46	91	203	311	623	1,039	1,770	3,711	6,518	10,320	21,020
400	19	43	85	190	291	583	972	1,656	3,472	6,098	9,655	19,660
450	18	41	80	179	275	550	917	1,562	3,275	5,752	9,107	18,550
500	17	39	76	170	261	522	870	1,482	3,107	5,457	8,640	17,600
550	16	37	73	162	249	498	830	1,414	2,964	5,206	8,243	16,790
600	15	35	70	155	239	478	796	1,356	2,844	4,996	7,909	16,110

EXTRACTS

DRAFT CODE CGA B 105

Digester Gas Distribution System

5 DIGESTER GAS DISTRIBUTION SYSTEM

5.1 General

5.1.1 Installation of piping systems shall be performed by authorized persons and where plastic piping is used shall be installed in accordance with the manufacturer's installation instructions.

5.1.2 Digester gas piping shall take the most direct route, contain as few elbows, drops and risers as is practicable, be of sufficient size to accommodate the maximum load requirements and when installed shall be at least equal to the applicable requirements of the current code CGA B149.1 INSTALLATION CODE FOR NATURAL GAS BURNING APPLIANCES AND EQUIPMENT corrected to the appropriate calorific value and relative density.

5.1.3 For isolation and purging purposes, every run of digester gas pipe shall have a manual plug or ball type shut-off valve, approved for the application, installed at either end and at any junction.

5.1.4 The installation of digester gas piping and tubing systems shall conform to the applicable sections of the part of the current CGA B149.1 INSTALLATION CODE FOR NATURAL GAS BURNING APPLIANCES AND EQUIPMENT covering PIPING AND TUBING SYSTEMS, HOSE AND FITTINGS.

5.1.5 For the purposes of this Code, digester gas is considered dry if its dewpoint is 2°C below the lowest temperature to which it will be exposed in any part of the system.

5.2 Materials

5.2.1 Pipe and fittings made of the materials listed below can be utilized for digester gas piping and tubing systems.

a) Stainless Steel
b) Alloy Steel
c) Plastic
d) Ductile Iron
e) Carbon Steel
f) Copper

5.2.2 For dry digester gas, any materials specified under C.G.A. B149.1 code may be used.

Designers and owners are warned that some of the material allowed within this code as quoted from existing regulations may not have a life expectancy applicable to the design use. Thus caution must be exercised in the interest of safety when selecting and specifying material to be utilized.

5.2.3 Components and accessories used in the system and made of cast iron or cast aluminum are acceptable (e.g. traps, flame arresters, etc.).

5.2.4 Cast iron pipe and fittings (including flanges) other than ductile shall not be used.
Note- This is a listed Prohibited Practice.

5.2.5 All gaskets and seals shall be of a soft neoprene (e.g. Shore Durometer hardness of 40) or other material capable of positively resisting the action of the digester gas.

5.3 Piping, Tubing and Fittings

The digester gas piping and tubing systems shall be fabricated of the materials given above in Section 5.2 depending on the particular installation and shall meet the provisions of the following applicable clauses:

5.3.1 Stainless Steel Piping and Fittings

5.3.1.1 Type 316, or 316L, Stainless Steel pipe and fittings may be used for above-ground installations.

5.3.1.2 Type 316, or 316L, Stainless Steel pipe and fittings may be used for underground (buried) installations where acceptable to the enforcing authorities.

5.3.1.3 Stainless Steel pipe, tubing and fittings for above ground installations may be fabricated of three types:

a) Type "A"

Pipe in sizes 1/2" to 12" (12.7 to 304.8 mm) shall be of Schedule 5S in accordance with ANSI B36.19. The fittings shall be of Schedule 10S taper-bored to Schedule 5S, buttwelding type in accordance with MSS SP-43 and ANSI B16.9.

b) Type "B"

Shop fabricated stainless steel piping in sizes: 1-1/2" to 8" (38.1 to 203.2 mm) Z shall be of U.S.S. #14 gauge, in sizes 10" and 12" (254 to 304.8 mm) of U.S.S. #12 gauge, in sizes: 14" to 18" (355.6 to 457.2 mm) of U.S.S. #11 gauge in accordance with ASTM-A-240.

c) Type "C"

Tubing

Note: For full description of applicable stainless steel pipe, tubing, fittings, flanges and gaskets, see Appendix.

5.3.1.4 Stainless steel pipe for the underground (buried) installations in sizes: 1/2" to 12" (12.7 to 304.8 mm) shall be of Schedule 40S in accordance with ANSI B36.19. The fittings shall be of Schedule 40S, butt-welding type in accordance with MSS SP-43 and ANSI B16.9.

5.3.2 Alloy Steel Piping and Fittings

5.3.2.1 Alloy steel pipe conforming to the current requirements of ASTM A714 High Strength Low Alloy Welded and Seamless Steel Pipe (e.g. "yoloy" steel pipe) may be used only where acceptable to the enforcing authorities.

5.3.2.2 Alloy steel pipe shall have a thickness not less than standard weight.

5.3.2.3 Fittings used with alloy steel pipe shall be Class 150 (Standard weight) malleable iron threaded fittings conforming to ANSI B16.3 Code.

5.3.3 Plastic Piping and Fittings

5.3.3.1 The plastic piping system, including pipe and fittings shall be made of polyethylene and shall conform to the current standard CSA B137.4 THERMO-PLASTIC PIPING SYSTEMS FOR GAS SERVICE.

5.3.3.2 Joining of plastic pipe shall be done in conformance to the current standard CSA Z184 GAS PIPELINE SYSTEMS.

5.3.3.3 Mechanical compression type flexible or non-flexible joining methods and fittings are not acceptable for use with plastic pipe except for earth buried underground installations and where used shall be acceptable to the enforcing authorities.

5.3.3.4 Plastic pipe shall not be installed for any use other than that which is acceptable to the enforcing authorities.

5.3.3.5 Plastic pipe shall not be subjected to external or internal temperatures in excess of its temperature rating and in no case more than 38°C as may occur downstream of a gas compressor.

5.3.3.6 Plastic pipe that is adversely affected by the sun's rays where installed out-of-doors, shall be effectively shielded from the sun's rays.

5.3.3.7 Plastic pipe shall be properly installed and supported to maintain a uniform designed slope.

5.3.3.8 Plastic pipe when installed shall have allowance for expansion and contraction as specified by the manufacturer.

5.3.4 Ductile-Iron Piping and Fittings

5.3.4.1 Ductile-iron pipe shall conform to the current standard CSA B131.14 DUCTILE-IRON PIPE, CENTRIFUGALLY CAST IN METAL MOULDS, OR SAND-LINED MOULDS FOR GAS.

5.3.4.2 Flanged ductile-iron pipe shall conform to the current standard CSA B131.17 FLANGED CAST-IRON AND DUCTILE-IRON PIPE WITH THREADED FLANGES.

5.3.4.3 Ductile-iron fittings, 4 inch (101.6 mm) through 24 inch (610 mm) shall conform to the current standard CSA B131.15 GRAY-IRON AND DUCTILE-IRON FITTINGS 3 INCH THROUGH 24 INCH FOR GAS.

5.3.4.4 Where ductile iron pipe is used,

a) Above ground; pipe joints shall be flanged (threaded flanges are acceptable), Class 125 conforming to ANSI B16.1 and ASTM A-47 standards.

b) Underground (buried); pipe joints shall be made with ductile-iron mechanical compression type joints with neoprene gaskets conforming to the current standard CSA B131.10 (ANSI A21.11) where acceptable to the enforcing authorities. (See also clause 5.8.12).

5.3.5 Carbon Steel Pipe and Fittings

5.3.5.1 Carbon steel pipe conforming to the current standard ANSI B36.10 and fabricated to ASTM A-120 and API 5L specifications for welded and seamless pipe, or equivalent may be used only where acceptable to the enforcing authorities.

Where used, carbon steel pipe shall have a thickness to comply with CGA B149 Code, Section 10.

5.3.5.2 Carbon steel pipe shall not be used for underground, buried installations. Note: This is a listed Prohibited Practice.

5.3.5.3 Pipe joints shall be threaded, flanged or welded.

5.3.5.4 For pipe over 65 mm (2-1/2") screwed joints shall not be used. Note- This is a listed Prohibited Practice.

5.3.5.5 The following types of fittings shall be used with carbon steel pipe of standard weight:

a) Class 150 or Class 300 maileable iron threaded fittings conforming to ANSI B16.3 standard.

b) Carbon steel welding fittings for use with steel pipe conforming to ANSI B16.9 standard and fabricated to ASTM A234 specification.

c) Forged steel flanges, Class 150 for use with standard steel pipe or welding fittings conforming with CSA Z245.10.

5.3.6 Copper Tubing and Fittings

5.3.6.1 Copper tube shall only be used for vent lines and bleed lines and shall be Type 'K' hard temper conforming with ASTM Designation B88 and have an internal cross-sectional area of not less than 80 mm^2 (square millimeters).

5.3.6.2 Fittings used with copper tube shall be flared or compression type.

5.3.6.3 Solder-joint fittings and connections shall not be used. Note - This is a listed Prohibited Practice.

5.4 Inspection Points

5.4.1 To permit permit periodic internal inspection of the piping system, at least one inspection spool of the same material as the pipe not less than 300 mm in length, shall be provided at an appropriate, readily accessible, low point in a horizontal run of the system carrying wet gas. A similar spool shall be provided in a run carrying dry gas.

Other inspection points may be provided with tee's (blank flange) or elbows. Manual plug or ball type valves are to be installed up and down stream of the spool to allow isolation and removal of the spool and to permit internal inspection of the pipe upstream and downstream of the spool. Large plants with extensive piping systems and extensions to existing systems will require additional inspection spools in recognizable problem areas.

5.5 Purging

5.5.1 To permit purging the whole or part of the system, purge points shall be provided in the piping at each branch system manual shut-off valve, at both sides of the valve, if applicable, and at other necessary points in the system. The purge points shall be not less than 1/2" (12.2 mm) nominal pipe size, fitted with a manual plug or ball type shut-off valve, which shall be plugged or capped.

5.5.2 Purge points shall be located so as to avoid deposition of sediment.

5.5.3 Digester gas piping before being put into service shall be purged of air and before being removed for inspection repair or replacement shall be purged of digester gas. Purging shall be done using only carbon dioxide or nitrogen gas (except as noted in 5.5.4) to not more than the maximum positive pressure setting of the waste gas burner excess pressure relief valve but shall not be excess of 20 kPa whichever is lesser.

5.5.4 Underground digester gas piping may be purged hydrostatically instead of using carbon dioxide or nitrogen.

5.5.5 All other purging procedures shall be carried out as outlined in CGA B149.1 INSTALLATION CODE FOR NATURAL GAS BURNING APPLIANCES AND EQUIPMENT. (The American Gas Association Publication AGA PURGING PRACTICES AND PROCEDURES is also recommended as good practice).

5.6 Pressure Testing Piping

5.6.1 New underground piping shall be hydrostatically tested before back-filling to 700 kPa for a duration of one hour with zero leakage.

5.6.2 All new piping in the gas system located inside buildings and connecting pipeways shall be pressure tested with air or inert gas to 1 1/2 times rated working positive pressure or 20 kPa whichever is the greater for a minimum of 1 h and a soap solution used for leak detection.

5.7 Gas Piping Passing through Walls and Partitions

5.7.1 When gas piping passes through walls or partitions, it shall be protected from direct contact with the wall or partition construction material, and the wrapper or coating shall not restrain longitudinal movement of the pipe.

5.7.2 Inside Walls and Partitions

5.7.2.1 Where a metal sleeve is used to protect gas piping through an inside wall or partition the metal used shall be of a material resistant to corrosive action from the construction material used in the wall or partition, or the outside surface of the metal sleeve shall be coated or wrapped with a corrosion resistant material.

5.7.3 Outside Walls

5.7.3.1 Where a metal sleeve is used to protect gas piping through an outside wall the metal used shall be of a material resistant to corrosive action from the construction material used in the wall, or the outside surface of the sleeve shall be coated or wrapped with a corrosion resistant material and the remaining space between the outside surface of the sleeve shall be caulked with a corrosion resistant caulking material to provide a water seal.

5.7.4 See also Clause 12.3

5.8 Underground Piping

5.8.1 Underground piping material shall be as in clause 5.2.2 and the use of cast iron pipe is prohibited.

5.8.2 Underground piping other than plastic shall be wrapped or coated with an asphaltic compound or an equivalent corrosion protection.

5.8.3 Underground piping shall be at a depth below frost level.

5.8.4 Underground piping shall have a minimum of 150 mm of tamped sand all around before backfilling.

5.8.5 When piping is laid or intended to be under hardtop, pavement, or roadway for its entire length or when the hardtop or pavement extends for 7.5 m or more of its length the pipe shall be placed in a casing of not less than 50 mm larger internal diameter. The casing shall be of a material acceptable for the application.

5.8.6 The casing shall be sealed at each end and a vent pipe of not less than 2 inch (50.8 mm) nominal pipe size shall be installed at each end extending above the ground and shall be constructed so as to prevent water from entering the casing.

5.8.7 The termination of each vent shall be not less than 600 mm above grade level, shall be provided with an 180° bend with bug screen, or equivalent and shall be protected against physical damage.

5.8.8 Underground pipe casing material shall have a smooth interior to prevent damage to the gas pipe and shall be acceptable to the enforcing authorities.

5.8.9 Short lengths of underground piping shall have a 2% slope with the low end located in the building at which there shall be installed a manual drip trap.

5.8.10 Long lengths of underground piping where it is not practical to have one continuous slope may be installed with the required slope in two or more directions from a common high point providing a manual drip trap is located inside the building (s) at each low point. (See also part 8).

5.8.11 Underground piping shall not be installed with threaded fittings. Note- This is a listed Prohibited Practice.

5.8.12 Mechanical compression type flexible or non-flexible joining methods and fittings may be used for earth buried underground installations where acceptable to the enforcing authority. (See also clause 5.3.4.4).

5.9 Gas Piping Identification

5.9.1 Plastic piping systems shall be permanently marked every linear 3 m with the maximum rated operating temperature of the plastic material.

5.9.2 All piping and fittings shall carry a manufacturer's identification as to material.

5.9.3 All gas piping and controls shall be painted or colour coded with high visibility yellow orange paint and each system of piping shall be labeled every linear 3 m with the name of the gas being conducted and the direction of flow.

APPENDIX

TO

INSTALLATION CODE FOR DIGESTER GAS SYSTEMS

CGA B 105

Stainless Steel Pipe and Fittings

1. The following pipe and fittings fabricated of Type 316 stainless steel may be used for the above-ground installations:

Type A

a) Pipe in sizes: 1/2" to 12" (12.7 to 304.8 mm) shall be of Schedule 5S in accordance with ANSI B36.19.

b) Fittings for the above described Schedule 5S pipe shall be of Schedule 10S, taper-bored to Schedule 5S, butt-welding type in accordance with MSS SP-43 and ANSI B16.9.

c) Flanges for the Schedule 5S pipe shall be MSS 150 pound, forged stainless steel, slip-on or welding neck type in accordance with ANSI B16.5 and MSS SP-4Z.

Type B

a) Stainless steel pipe in sizes: 1½" to 8" (38.1 to 203.2 mm) inclusive shall be of U.S.S. #14 gauge, in sizes: 10" & 12" (254 to 304.8 mm) of U.S.S. #12 gauge and in sizes: 14" to 18" (355.6 to 457.2 mm) inclusive of U.S.S. #11 gauge in accordance with ASTM-A-240.

b) Fittings for the stainless steel pipe fabricated of U.S.S. #11, 12 and 14 gauges shall be of stainless steel, pressed type with stainless steel pressed Van-Stone or rolled Van-Stone ends compatible with the pipe and in accordance with ASTM-A240.

c) Flanges for the stainless steel piping fabricated of U.S.S. #11, 12 and 14 gauges shall be 125 lb. to ANSI B16.1 and ASTM-A7 carbon steel backing flanges. Flanges shall be cleaned by commercial type blasting to SSPC-SP6-63 and protected with a minimum of one coat of coal-tar epoxy to a minimum dry-film thickness of 4 mils.

Note:

a) The stainless steel pipe and fittings(Type B) fabricated to the above-specified U.S.S. gauges shall be designed to withstand pressure of 150 p.s.i.g.

b) Gaskets for all the above-specified flanges should be of 1/8" (3.17 mm) thick neoprene suitable for the type of flange.

II. The following stainless steel pipe and fittings fabricated of 316 stainless steel may be used for the underground (buried) installations:

a) Pipe in sizes: 1/2" to 12" (12.7 to 304.8 mm) inclusive shall be of Schedule 40S in accordance with ANSI B36.19.

b) Fittings shall be Schedule 40S, butt-welding type in accordance with MSS-SP-43 and ANSI B16.9.

c) Flanges shall be ANSI 150 pound, forged stainless steel, slip-on or welding neck type to ANSI B16.5.

d) Gaskets shall be of 1/8" (3.17 mm) soft neoprene, ring type.

SUBJECT:

NATURAL GAS, PROPANE AND FUEL OIL

TOPIC: 4

FUEL CHARACTERISTICS AND INSTALLATION CODES

OBJECTIVES:

The trainee will be able to:-

1. Recall the important characteristics of Natural Gas, Propane and Fuel Oil including:-
   a) Composition
   b) Heating Value
   c) LEL and UEL
   d) For fuel oil, flashpoint and ignition point and grade
2. Recall and make use of the Installation Codes for Natural Gas, Propane and Fuel Oil as they apply in a Digester Gas Distribution System.

FUEL CHARACTERISTICS AND INSTALLATION CODES

GENERAL

In a wastewater treatment plant incorporating sludge digestion there are four fuels which one should be familiar with.

1. Fuel oil, used for boilers
2. Natural gas, also used in some cases as a fuel for boilers.
3. Propane gas used for the ignition pilots of boilers and waste gas burners
4. Digester gas used as a fuel for boilers to reduce energy costs (see topic 3)

The use of any fuel is governed by a code for the installation of burning appliances and equipment. Extracts of the following are attached:-

1. CGA B149.1-1976 Installation code for Natural Gas Burning Appliances and Equipment Appendix A
2. CGA B149.2-1976 Installation code for Propane Burning Appliances and Equipment Appendix B
3. CSA Standard B139-1971 Installation code for Oil Burning Equipment Appendix C

FUEL CHARACTERISTICS

The principal characteristics of a fuel which are of importance are:

1. Composition
2. Heating value expressed in British Thermal Units (BTUs)
3. Lower Explosive Limit (LEL) and Upper Explosion Limit (UEL) for gases
4. For fuel oils the grade, flashpoint and ignition point

A summary comparing the characteristics of Digester Gas, Natural Gas, Propane and fuel oil is attached as Appendix D.

Natural Gas

Natural gas is a fossil fuel which is found below the earth's surface. In its original state it has hydrogen sulphide in it. At the well head this is removed by scrubbing because of its corrosiveness and a foul smelling compound, Mercaptan, is added to ensure that the natural gas can be detected by smell below the LEL. It is then piped under pressure to the user.

The composition of natural gas varies, but its principal component is Methane (94-95%). It has a heating value of approximately 1000 BTU per cubic foot.

Natural gas is non toxic, non corrosive gas. It is clean burning but explosive when mixed with air. The LEL is 4.9% and the UEL 15%. Natural gas which is lighter than air tends to dissipate and become diluted when released from a confined space.

Propane Gas

It is a costly fuel which requires special pipes and storage tanks. It is only used in treatment plants as a fuel for ignition pilots. Propane is a by-product of natural gas and crude oil.

Sold as a liquid in cylinders it has a heat value of about 2500 BTU per cubic foot. The LEL is 2.1% and the UEL is 10.1%. Being heavier than air it sinks to ground level if released, filling up low lying areas. It does not dissipate easily.

Fuel Oil

Fuel oils are the products or by products of the distillation of crude oil. The higher the grade of oil the heavier it is. Thus #1 grade fuel oil is the type of oil used in vaporizing or wick type burners. Number 6 is a very heavy type which requires pre-heating before it can be pumped to the burner. In a wastewater treatment plant #2 fuel oil with a flashpoint of about 40°C is most commonly used.

Fuel oil is composed of compounds of carbon and hydrogen with small amounts of oxygen sulphur and nitrogen. No. 2 fuel oil has a heating value of 18,000 - 19,000 BTU/lb at 60°F.

STORAGE OF FUELS

Since natural gas is metered to the user and digester gas is wasted through a burner if not used, only the onsite storage of fuel oil and propane need be considered. As mentioned earlier, the storage conditions are established in the Applicable Installation Codes.

Fuel Oil

Section 6 of CSA Standard B 139-1971 Installation Code for Oil Burning Equipment attached as Appendix C covers the minimum requirements for the installation of,alteration to and provision for maintenance of oil supply tanks. These should be carefully reviewed. The following subsections are of particular importance:

1. Subsection 6.2.4
2. Subsection 6.3 Tanks Installed Underground
3. Subsection 6.4 Supply Tanks Inside Buildings
4. Subsections 6.6 and 6.7 Supply Tanks Installed Above Ground Outside
5. Subsection 6.8 Filling of Supply Tanks
6. Subsection 6.9 Venting of Supply Tanks, including Table 3
7. Subsection 6.10 Gauging of Supply Tanks

Propane Gas

Section 12 of CGA 149.2-1976 Installation Code for Propane Burning Appliances and Equipment covers the requirements for Cylinder Systems. Of particular importance are:

1. Section 12.5.3 Storage of Cylinders Awaiting Use -- General
2. Section 12.5.4 Storage of Cylinders for Use Outdoors

CGA
B149.1-1976

EXTRACTS FROM
INSTALLATION CODE
FOR
NATURAL GAS
APPLIANCES AND EQUIPMENT

3. GENERAL REQUIREMENTS

3.3 Workmanship

3.3.1 All work shall be done in a workmanlike manner. Careful attention shall be paid not only to the mechanical execution of the work but also to the arrangement of the installation.

3.3.2 Personnel performing installation, operation, and maintenance work shall be properly trained in such functions.

3.5 Checking for Gas Leaks

3.5.1 Matches, candles, flame, or other sources of ignition shall not be used to check for gas leaks.

3.5.2 Lights, including flashlights used in connection with a search for gas leakage shall be restricted to Class 1 Group D type. Electric switches in or adjacent to the area of leakage shall not be operated unless of this classification.

3.6 Smoking

3.6.1 Smoking or providing any source of ignition shall not be permitted in the area where work is being done on piping, tubing or equipment which contains or has contained gas unless the piping, tubing or equipment has been purged of all gas as outlined in Section 10.24.

4. INSTALLATION REQUIREMENTS FOR APPLIANCES AND EQUIPMENT

4.2 Location

4.2.1 Unless directly vented to the outdoors, appliances shall be positioned as close as practicable to an existing chimney or vent.

4.3 Appliance Connections

4.3.1 Approved flexible metal connectors not more than 2 ft in length, may be used to connect the appliance to piping.

4.4 Appliance Clearances

Type of Protection†	Where the Required Clearance With No Protection Is:										
	36 inches			18 inches			12 inches		9 inches	6 inches	
	Above	Sides and Rear	Flue Pipe	Above	Sides and Rear	Flue Pipe	Above	Sides and Rear	Flue Pipe	Above	Sides and Rear
a) ¼-in asbestos millboard spaced out 1 in	30	18	30	15	9	12	9	6	6	3	2
b) No 28 MSG sheet metal on ¼-in asbestos millboard	24	18	24	12	9	12	9	6	4	3	2
c) No 28 MSG sheet metal spaced out 1 in	18	12	18	9	6	9	6	4	4	2	2
d) No 28 MSG sheet metal on ¼-in asbestos millboard spaced out 1 in	18	12	18	9	6	9	6	4	4	2	2
e) 1¼-in asbestos cement covering on heating appliance	18	12	36	9	6	18	6	4	9	2	1
f) ¼-in asbestos millboard on 1-in mineral wool batts reinforced with wire mesh or equivalent	18	12	18	6	6	6	4	4	4	2	2
g) No 22 MSG sheet metal on 1-in mineral wool batts reinforced with wire mesh or equivalent	18	12	12	4	3	3	2	2	2	2	2
h) ¼-in asbestos cement board	36	36	36	18	18	18	12	12	9	4	4
i) ¼-in cellular asbestos	36	36	36	18	18	18	12	12	9	3	3

* All clearances given in inches

† Except for the protection indicated in (e) above, all clearances shall be measured from the outer surface of the appliance to the combustible material disregarding any intervening protection applied to the combustible material, but in no case shall the clearance be such as to interfere with the requirements for combustion air and for accessibility

‡ Applied to the combustible material unless otherwise specified and covering all surfaces within the distance specified as the required clearance with no protection. Thicknesses are minimum

NOTE Spacers shall be of non-combustible material

TABLE 4.4.2

Clearance* With Specified Forms of Protection

4.6 Responsibilities of the Installer

4.6.1 Before leaving any installation, the installer shall ensure that all appliances installed by him are in safe working order.

4.11 Shut-Off Valves

4.11.1 A readily accessible shut-off valve of an approved type shall be installed in the supply piping or tubing to each appliance.

5. REQUIREMENTS FOR THE INSTALLATION OF SPECIFIC TYPES OF APPLIANCES

5.1 Boilers

5.1.3 Boilers shall be installed with the following minimum clearances from combustible material; vertical, 18 in; sides and rear, 18 in; front, 48 in.

5.17 Room Heaters and Gas Logs

5.17.1 Room Heaters in bathrooms shall be of the sealed combustion unit type.

5.26 Sealed Combustion Units

5.26.1 Vent terminals of sealed combustion units shall be located not less than 9 in from any building opening. A sealed combustion unit may be installed in a building opening, such as a window.

6. AIR FOR COMBUSTION, VENTING AND VENTILATION

6.1 Appliances shall be installed in locations where there is a sufficient air supply for combustion air, venting and ventilation air.

6.1.1 Appliances shall be located in such a manner as not to interfere with the proper circulation of the air supply. When buildings are so tightly sealed that infiltration does not meet the air supply requirements, outside air supply shall be provided.

6.1.2 Ducts used to convey air supply to or from the outdoors shall be of metal or other noncombustible material and shall be of the same cross-sectional area as the free area of the opening to which they connect. The smaller dimension of rectangular ducts shall not be less than 3 in.

6.1.3 When air supply is required from the outdoors in Clause 6.1.4 or Section 6.3, and the air supply is for natural draft or fan assisted burners, the bottom of the air supply opening or the termination of the air supply duct shall be not more than 18 in nor less than 6 in above the floor level.

6.1.4 When a number of appliances having a combined input exceeding 400,000 BTUH are installed in a single enclosure, the air supply requirements shall be calculated in accordance with Sections 6.2, 6.3 or 9.1.

6.1.5 Responsibility for the proper and adequate venting of all types of appliances shall rest with the installer.

6.4 Dampers, Louvres and Grilles

6.4.2 Apertures in fixed louvres, grilles or screens shall have no dimension smaller than ¼in.

6.4.3 Manually operated dampers or manually adjustable louvres shall not be used.

6.4.4 Automatically operated dampers or automatically adjustable louvres shall be interlocked so that the main burner cannot operate unless the dampers or louvres are in the fully open position.

6.8 Venting of Appliances

6.8.1 Every appliance shall be connected to an effective chimney or vent except:

a) radiant heaters installed in masonry fireplaces with approved permanent openings that provide venting;

b) a domestic appliance which is approved for use without a vent;

c) appliance installations in buildings where adequate ventilation is provided by exhaust fans, natural draft ventilators, or by other effective means acceptable to the enforcing authority;

d) appliances installed for the production of carbon dioxide in greenhouses where the rate of combustion does not exceed 3 Btuh for each cu ft of greenhouse volume and the concentration of carbon dioxide in the atmosphere does not exceed 5,000 per million (0.5%); and

e) as provided in Section 6.19.

6.9 Methods of Venting Appliances

6.9.1 Vents and chimneys shall be designed and constructed so as to develop a positive flow adequate to remove all vent gases to the outdoors.

6.9.3 Type B vents shall be used only with appliances that are certified with a draft hood except as provided for in Clauses 6.9.2, 6.9.4 and 6.19.2. Vent connectors using Type Be vent material shall not be used between the draft hood and flue outlet of a converted furnace or boiler.

6.9.4 Type BW vents shall be used only with recessed wall furnaces.

6.11 Chimneys

6.11.6 When a chimney serving appliances burning solid or liquid fuels also serves gas appliances, the flue pipe connections for venting gas appliances shall be above the flue pipe connections from the other appliances (see also Clause 6.17.18).

6.11.7 All chimneys shall be provided with a cleanout opening. Cleanouts shall be of such construction that they will remain tightly closed when not in use. Tee fittings used as cleanouts or condensate drains shall have tight fitting caps to prevent entrance of air into the chimney at that point.

6.13 Vent or Chimneys shall extend high enough above the building or other neighbouring obstruction so that wind from any direction will not create a positive pressure in the vicinity of the vent or chimney termination.

6.13.2 Vents and chimneys shall extend above the highest point where they pass through the roof of a building:

a) in accordance with Table 6.13.2 and at least 2 ft higher than any portion, including roof surfaces and parapets, of a building with 10 ft horizontally; or

b) chimneys shall extend at least 3 ft above the highest point where they pass through the roof of a building, and at least 2 ft higher than any portion of a building within a horizontal distance of 10 ft.

TABLE 6.13.2

Termination Height for Gas Vents and Chimneys Above Flat Roof

Nominal Inside Diameter, In.	Minimum Termination Height, In.
4 or less	24
5	30
6	36
7	48
8	60
10	66
12 and larger	72

6.13.3 Vents and chimneys shall terminate not less than 5 ft in height above the highest connected appliance draft hood outlet or flue collar except as provided in Clause 6.19.1.

6.13.5 Vents shall terminate:

a) in a location where flue or vent gases cannot circulate into combustion air inlets of adjacent appliances nor into building air inlets and the terminations shall be not less than 6 ft from any such inlet; and

b) not less than 3 ft from any other building openings.

6.17 Vent connectors

6.17.3 Except as provided in Clause 6.17.10, the minimum clearances of vent connectors of Type B vent material, including passage through combustible walls or partitions, shall be in accordance with Table 6.17.8.

TABLE 6.17.8

Clearances for Appliance Vent Connectors

Appliance	Minimum Distance from Combustible Material (Inches)	
	Type B Vent Connectors	Other Than *Type B Vent Connectors*
Boiler	1*	6
Warm Air Furnace	1*	6
Service Water Heater	1*	6
Space Heater	1*	6
Floor Furnace	3†	9
Incinerator	Not Permitted	18
Conversion Burner (with *draft hood*)	6	9

* Except as otherwise certified
† 3 in for a distance of not less than 3 ft from the outlet of the *draft hood*. Beyond 3 ft, the minimum clearance is 1 in.

6.17.18 Chimney Connections

6.17.18.2 The vent connector shall not protrude into the chimney to obstruct the chimney flue.

6.17.18.3 A sleeve shall be used to facilitate removal of the vent connector for cleaning.

6.18 Draft Hoods

6.18.1 Every appliance requiring zero over-fire draft for operation shall be installed with a draft hood, except an incinerator, dual oven type combination range, or a sealed combustion unit.

6.25 Induced or Forced Draft

6.25.1 When induced or forced draft devices are used, provision shall be made to prevent flow of gas to the burners on failure of these devices.

7. REQUIREMENTS FOR THE FIELD CONSTRUCTION OF APPLIANCES

7.3 Pilots and Pilot Supply Piping or Tubing

7.3.5 Subject to Clause 7.2.2 the gas supply to pilots shall be through piping or tubing firmly secured and shall be connected to the main gas supply line

a) at a point upstream of the appliance pressure regulator when the supply pressure is not in excess of 1/2 psig.

b) at a point upstream or downstream of the appliance pressure regulator when the supply pressure is in excess of 1/2 psig.

7.3.6 Pilots shall be independently controlled by a 1/4 turn shut-off valve located upstream of all other components of the pilot.

7.6 Safety Shut-Off Valves

7.6.1 When required to be installed, safety shut-off valves shall meet the following requirements:

a) be certified,

b) have a pressure rating not less than that of the protected pressure upstream of the burner valve train,

c) every electrically operated automatic valve and electrically operated safety shut-off valve shall shut off the supply of gas where there is a failure of the electrical current,

d) be capable in normal operation of opening only when activated by the energizing medium(s) and shall be constructed so that they cannot be manually opened nor readily blocked in the open position,

e) be provided with means for an easy, sensitive test for tightness when in the closed position,

f) be of the manual reset type, or provided with a mandatory manual reset function to open, for manually lighted burners.

g) be so located that, when in the closed position, no gas can flow into the combustion space of the appliance, and

h) not be bypassed except with the approval of the enforcing authority and they bypass is equipped with shut-off valves capable of being locked in the closed position.

7.7 Combustion Air Adjustment

7.7.1 When shutters for combustion air are provided, they shall be capable of any desired adjustment and provided with means for preventing accidental changes in settings.

7.7.2 Shutters for combustion air shall be constructed and mounted in a workmanlike manner ensuring that munimal air leakage can take place around shutters.

7.7.3 The combustion air shall be introduced in such manner to ensure thorough mixing of the gas and air in order that complete combustion may occur within the space provided.

7.7.4 When automatically operated air controls are provided, the arrangement shall be such that, in case of failure, maximum air flow shall be provided or the gas shall be shut off.

7.7.5 Where combustion air supply is by mechanical means, gas shall be prevented from entering the burner until the air flow is proven by a differential air flow switch or acceptable equivalent and, in the event of failure of the required air flow, the gas shall be automatically shut off.

7.7.6 On appliances where the firing rate is automatically changed, the air-gas ratio shall produce stable conditions at all firing rates without manual attention.

7.8 Electric Ignition and Control Devices

7.8.2 Electric ignition systems shall ignite only a pilot except on approved factory assembled appliances, or as provided in Section 7.9.

7.9 Electric Spark Ignition

7.9.1 Direct transformer spark shall not be used to ignite a pilot unless the pilot is monitored.

7.9.2 Direct transformer spark shall not be used to ignite a main burner unless:

a) the spark is of the interrupted type,

b) the main burner is monitored,

c) the ignition transformer secondary is rated at not less than 6,000 volts and 20 milliamps,

d) the main burner has an input not in excess of 3,500,000 Btuh at time of ignition,

e) the location and setting of the electrodes are secure and provide reliable and smooth ignition,

f) the trial for ignition period of a burner with an input not in excess of 400,000 Btuh, shall not exceed 10 seconds,

g) the trial for ignition period of a burner with an input in excess of 400,000 Btuh, shall not exceed 5 seconds.

7.11 Temperature and Pressure Safety Limit Controls

7.11.1 Boilers shall be equipped with approved automatic devices of which the sole function shall be to shut down the burners in the event of undue pressure or low water in a steam boiler, or overheating in a water boiler.

7.11.2 Every automatically controlled furnace shall be equiped with an approved high temperature limit control, the maximum setting of which shall be 350F for a gravity furnace or 250F for a forced air furnace.

7.12 Isolation of Safety Limits or Safety Relief Devices

7.12.1 A safety limit or safety relief device shall not be isolated, bypassed or in any way made ineffective and valves or other devices shall not be installed which can cause isolation, bypassing or ineffective operation.

8. ADDITIONAL REQUIREMENTS FOR THE FIELD CONSTRUCTION OF HIGH PRESSURE OR HIGH VOLUME APPLIANCES (IN EXCESS OF ½ PSIG OR 400,000 BTUH)

8.1 Combustion Safety Controls (Flame Safeguards)

8.1.2 Combustion safety controls shall be constructed and installed so that gas cannot flow to the main burner, burner groups or pilots unless satisfactory ignition is ensured.

8.1.3 The trial for ignition period of intermittent and interrupted pilots and main flames shall not exceed 10 seconds.

8.1.4 Response time of combustion safety controls shall not exceed 5 seconds except as provided in Clause 8.1.5.

8.2 Main Burner Manually Operated Valves

8.2.1 Each burner unit shall be equipped with a firing test valve located downstream of all other controls except that it may be located upstream of either an input flow ratio control valve or a gas-air mixing valve.

8.2.2 The ahndle of a firing test valve, when in place and the valve is open, shall be parallel to the flow of gas and shall be capable of being turned to the on and off positions without removal of the handle.

8.3 Main Burner Safety Shut-Off Valves

8.3.1 When required to be installed, safety shut-off valves shall meet the following requirements:

a) be installed downstream from the main shut-off valve or isolation valve, when used, and downstream from the appliance pressure regulator, when required by Clause 7.2.1 and upstream of the firing test valve;

b) be slow opening, fast closing valves unless otherwise required by the appliance manufacturer and approved by the enforcing authority on appliances with inputs in excess of 1,000,000 Btuh;

c) be tested to assure gas tightness of the seats when in the closed position by shutting off gas to all burners by means of valves downstream from the safety shut-off valves.

CGA
B149.2-1976

EXTRACTS FROM
INSTALLATION CODE
FOR
PROPANE BURNING
APPLIANCES AND EQUIPMENT

7 REQUIREMENTS FOR THE FIELD CONSTRUCTION APPLIANCES

7.2 Appliance and Pilot Pressure Regulators

7.2.2 When an appliance pressure regulator is required by Clause 7.2.1 the propane supply to the pilots shall be regulated by an approved pressure regulator independent of the main burner propane supply.

7.2.7 Pressure regulators shall be equipped with a vent line leading outdoors in accordance with Clause 11.8.1

7.3 Pilots and Pilot Supply Piping or Tubing

7.3.1 Pilots shall be located, firmly secured and adequate to ensure safe and reliable ignition of the main burner.

7.3.2 The input to a continuous pilot shall not exceed 3% of the maximum rated input to the main burner.

7.3.3 The input to either an intermittent or interrupted pilot shall not exceed 5% of the maximum rated input to the main burner.

7.3.4 Where either an intermittent or interrupted pilot is used, the appliance control system shall provide, prior to the ignition cycle, a proven purge period equal to at least four air changes of the combustion zone and flue passages at an air flow rate of not less than 50% of that required at maximum input.

7.3.5 Subject to clause 7.2.2 the propane supply to pilots shall be through piping or tubing firmly secured and shall be connected to the main propane supply line.

7.3.6 Pilots shall be independently controlled by a ¼ turn shut-off valve located upstream of all other components of the pilot.

10. PIPING AND TUBING SYSTEMS, HOSE, AND FITTINGS

10.1 General

10.1.1 Propane piping or tubing systems shall be of steel piping and fittings and/or steel or copper tubing, all meeting the requirements of Section 10.2 used to convey propane from the point of supply to the inlets of appliances.

10.1.2 Piping, tubing and fittings shall be new, or used provided they have not been used for any other purpose than for conveying propane or gas, and shall meet the requirements of Clause 10.13.

10.2 Material

10.2.1 Steel piping shall be black and shall comply with CSA Standard B63, Welded and Seamless Steel Pipe.

10.2.2 Fittings used with steel pipe shall be of malleable Iron Fittings.

10.2.3 Propane vapour phase piping with operating pressures not exceeding 125 psig shall be at least Schedule 40. Vapour phase piping with operating pressures over 125 psig and all liquid piping shall be at least Schedule 80 if joints are threaded, or threaded and back welded. At least Schecule 40 shall be used if joints are welded or welded and flanged.

10.3.2 Piping and Tubing Systems Operating at Pressures ½ psig or Less

10.3.2.1 Piping and tubing systems operating at pressures ½ psig or less shall be designed so that the loss in pressure between last stage regulators and appliances shall not exceed 0.5 in w.c. The minimum size of pipe, tubing and fittings shall be in accordance with Appendix B.

12. CYLINDER SYSTEMS

12.5 Storage of Cylinders Awaiting Use or Sale

12.5.3 General

12.5.3.1 Cylinders in storage shall not be exposed to temperatures in excess of 125F, open flames or similar sources of ignition, or damage, and be protected from tampering by fencing or equivalent method of protection.

12.5.3.2 Cylinders, empty or filled, which require cylinder valve protecting caps shall have such caps in place while in storage.

12.5.3.3 Cylinders which have been in service shall be stored outdoors.

12.5.3.4 Cylinders in storage shall have the cylinder valves closed.

12.5.3.5 Subject to Section 12.5.8 cylinder storage areas, docks, buildings or special rooms, shall be located a minimum distance of 25 ft from adjoining line of property occupied by schools, churches, hospitals, athletic fields, or other points of assembly either public or private.

12.5.3.6 Areas beneath cylinder docks shall be well ventilated and enclosed, not necessarily by the fence specified in Clause 12.5.4.1, to prevent access and accumulation of combustible material, or the space shall be occupied by well tamped earth.

12.5.3.7 Readily ignitable material including weeds and long dry grass shall be removed from within 10 ft of any cylinder storage area.

12.5.3.8 The electrical equipment and fixtures installed within buildings or within special rooms used for the storage of cylinders shall be in accordance with Class I Division II for hazardous locations requirements of CSA Standard C22. 1, Canadian Electrical Code, Part I.

12.5.3.9 The electrical equipment and fixtures required for outdoor cylinder storage areas, that are installed within 25 ft, measured on a horizontal plane of the storage area, and 10 ft on a vertical plane above the cylinder relief valves, shall be in accordance with Clause 12.5.3.8

12.5.4 Storage of Cylinders for Use or Sale Located Outdoors

12.5.4.1 Subject to Clause 12.5.4.2 and Section 12.5.5 cylinders stored outdoors shall be fenced in accordance with one of the following methods:

a) (i) The fence shall be at least 6 ft high and may include three strands of barbed wire at the top, spaced 4 in apart.

12.5.4.2 Cylinders stored outdoors against an industrial building on the property of the user, may be stored meeting the requirements of Section 12.5.3 except the fencing required by Clause 12.5.4.1 is not mandatory, provided:

a) they are 25 ft from any other building, property line or points of assembly either public or private.

b) the quantity stored does not exceed 1,000 lb of propane,

c) the relief valves on the cylinders are not less than 3 ft horizontally from any building opening that is below the level of the relief valve discharge, and

d) the relief valve discharge is not less than 10 ft on a horizontal plane from the air intake of any appliance or air moving equipment.

12.5.4.3 "NO SMOKING" signs shall be prominently displayed at areas used for storing sylinders awaiting sale. These signs shall be in accordance with Clause 13.10.3.

13.2 Relief Valves

13.2.1 Each propane tank shall be provided with one or more relief valves meeting the requirements of the Boiler and Pressure Vessel Inspection Authority of the Province in which it is to be installed.

EXTRACTS FROM

CSA STANDARD B139-1971

INSTALLATION CODE

FOR

OIL BURNING EQUIPMENT

3. GENERAL REQUIREMENTS

3.6 Responsibility of Installer. After installation of, or after alteration to or addition to, oil burning equipment, the installer shall make certain that such equipment is operating in a safe and acceptable manner as recommended by the manufacturer in the instructions, and that all safety devices are functioning properly.

3.14 Fuel Oil Filter. A suitable fuel oil filter or strainer, shall be provided in the fuel supply line to the oil burner.

3.16 An emergency shut-off device

3.16.1 An emergency shut-off device shall be:

Provided on each oil burner installation, except on the installation of approved oil burning stoves with integral tanks, to manually stop the flow of oil to the burner.

4. VENTING AND AIR SUPPLY

4.1 General

4.1.1 When an oil burning appliance is located within a building, provision shall be made to vent the products of combustion safely to outside the building.

4.1.2 When an oil burning appliance is located within a building sufficient air for combustion of the oil and ventilation of the appliance shall be supplied to the space wherein the appliance is located.

4.2 Venting Products of Combustion

4.2.1 General. The venting facilities shall be adequate to assure no hazard from the products of combustion.

4.2.2.5 When forced or induced draft fans are used:

a) The chimney shall be capable of handling the flue gases when such fans are operating; and

b) Upon the failure of air-flow, the supply of fuel to the main burner shall be automatically shut off.

4.2.2.8 A chimney flue shall extend at least 3 feet above the highest point at which the chimney comes in contact with the roof, and not less than 2 feet above the highest roof surface or structure within 10 feet horizontally of the chmney. Not more than 8 inches of chimney flue above the top of the chimney cap may be considered in computing this height.

4.2.5 Flue Pipes

4.2.5.1 The flue pipe shall be in good condition and when used on appliances relying on natural draft it shall be not smaller in cross sectional area than the flue collar of the appliance.

4.2.6 Flue Pipe Dampers

4.2.6.1 A manually operated damper shall not be placed in the flue pipe of an oil fired appliance, except stoves using sleeve type burners or as permitted by Clause 4.2.6.2.

4.3 Air for Combustion and Ventilation

4.3.1 General

4.3.1.1 Oil burning appliances shall be installed only where:

a) An adequate supply of combustion air is available to assure proper combustion;

b) Ambient air temperatures are maintainedwithin safe operating limits; and

c) Provision is made to compensate for the air drawn from the area by other appliances such as exhaust fans, clothes dryers or fireplaces.

Note: See Appendix A for data on supply of air for combustion and ventilation.

5. TESTS

5.1 Tests and Observations. The following tests and observations shall be made, where applicable, after installation of, or after alteration to, or addition to, oil burning equipment:

a) Determine that correct components are installed;

b) For an atomizing type burner, observe that a nozzle of the correct spray type, capacity, and spray angle is installed. For a vaporizing type burner, determine that the flow rates are correct;

c) Determine that the fuel pump pressure is correct;

d) Determine that the operating controls are in satisfactory condition;

e) Determine that the limit controls will operate properly at the correct temperature and/or pressure;

f) Determine that the combustion safety control operates properly regarding:

(i) Draft in chimney, in flue outlet, and over-fire;
(ii) Smoke density of the flue gases;
(iii) Temperature of the flue gases;
(iv) Analysis of the flue gases;

h) Determine that all oil connections are tight

5.2 Requirements

5.2.1 Test Point Location

5.2.1.1 The location at which flue outlet draft and flue outlet temperature, and samples for smoke density and flue gas analysis are to be taken, shall be:

a) At the centre line of the flue pipe; and

b) Not more than 18 inches downstream from the flue collar; and

c) Between the flue collar and draft regulator, if used.

5.2.4 Temperature

5.2.4.1 The measured flue outlet temperature (total) of the flue gases shall not exceed 750F except when the equpment is approved for a higher temperature.

Note: The temperature sensing element should be shielded from radiant heat from any source upstream from the test location.

5.2.4.2 The measured temperature (total) of the flue gas at the entrance to the chimney shall be not less than:

a) 350F when less than 40 per cent of the chimney outer surface is exposed to outdoors; and

b) 400F when:

(i) More than 40 per cent of the chimney outer surface is exposed to outdoors; or

(ii) The chimney is unlined.

Note: Lower flue gas temperatures at the chimney or venting device may be permitted when adequate provisions are made for the effects of condensation.

5.2.5 Analysis of Flue Gases. The percentage of carbon dioxide in the flue gases shall be within the limits specified in the instructions.

5.2.6 Functioning of Safety and Operating Controls. The safety and operating controls shall function within the limits specified for the type of equipment.

5.2.7 Fuel Input. The fuel input shall not exceed the fuel input specified in the instructions for the equipment.

6. SUPPLY TANKS

6.2 Supports, Foundations and Anchorage for All Tank Locations

6.2.4 When a tank is located in an area that may be subjected to flooding, to prevent floating, the tanks shall be securely anchored to a concrete slab equal in weight to the displaced water.

6.3 Tanks Installed Underground

6.3.1 Spacing between two adjacent underground tanks shall not be less than two feet.

6.3.2 An underground tank shall be installed in such a manner that the foundation of any building will not be endangered, and shall be located so that the distance, measured horizontally from the nearest point of the shell to the nearest line of adjoining property that may be built on, or to the nearest outside wall of any basement or pit, shall be not less than 3 feet for tanks of 2,000 gallon or less capacity and not less than 10 feet for tanks of over 2,000 gallon capacity, unless a lesser distance is authorized by the authority administering this Code.

6.3.3 A tank shall not be installed under a building unless authorized by the authority administering this Code.

6.3.4 An underground tank shall:

a) Be placed in the excavation with care; and

b) Be set on a firm foundation; and

c) Be surrounded with at least 12 inches of non-corrosive inert materials, such as clean earth or sand, well tamped in place; and

d) (i) Be covered with a minimum of 3 feet of earth, on top of which shall be placed a slab of reinforced concrete not less than 4 inches thick.

(ii) Be covered with a minimum of 2 feet of earth, on top of which shall be placed a slab of reinforced concrete not less than 4 inches thick.

Note: Rolling a tank into position can break a weld, puncture or damage the tank metal or scrape off the protective coating.

6.3.5 When an underground tank is likely to be subjected to traffic, it shall be protected against damage by vehicles passing over the tank by:

a) At least 3 feet of earth cover, on top of which shall be placed a slab of reinforced concrete not less than 4 inches thick and extending at least 1 foot horizontally in all directions beyond the outline of the tank; or

b) At least 18 inches of well tamped earth, on top of which shall be placed a slab of 6 inches of reinforced concrete or 8 inches of asphaltic concrete, extending at least 1 foot horizontally in all directions beyond the outline of the tank.

6.3.8 All connections to an underground tank shall be made through the top of the tank except as permitted in Clause 10.

6.4 Supply Tanks, Installed, Unenclosed, Inside Buildings

6.4.1 Tanks unenclosed inside a building shall conform to the following:

a) A supply tank not larger than 10 gallons shall be specifically approved for the purpose;

b) An approved safety can may be used as a storage tank;

c) A supply tank larger than 10 gallons shall be constructed in accordance with Clause 6.1.2;

d) A tank shall be of such size and shape that it can be installed in and removed from the building as a unit;

e) The capacity of an auxiliary supply tank shall not be more than 50 gallons.

6.4.3 In the lowest storey, cellar, or basement of any building, the capacity permitted shall be in accordance with the following:

a) The capacity of any one tank shall not exceed 500 gallons; and

b) The total capacity of tanks shall not exceed 1,00 gallons unless fire separation having a fire resistance rating of not less than two hours is provided for each 500 gallons of tank capacity (see Clauses 6.5.5 and 6.5.6).

c) When the total capacity of tanks connected to one supply line exceeds 500 gallons, all connections shall be through the top of the tank, and the transfer of oil to and from the consuming appliance, shall be by pump only and through continuous piping.

6.4.4 A tank, unenclosed, shall be located:

a) So that the temperature of the oil in the tank will not exceed 100F; and

b) So that the horizontal distance from the tank to any fuel fired appliance shall not be less than 5 feet except when approved as part of an appliance or as permitted by Clause 6.4.5.

6.4.7 A shut-off valve shall be provided immediately adjacent to the burner supply connection at the supply tank.

6.6 Supply Tanks, Not Over 500 Gallon Capacity, Installed Outside Aboveground

6.6.3 Tanks shall not block means of egress from a building.

Note: Means of egress is generally considered to provide a clearance to the tank of 5 feet, in any direction from the door or lowest step.

6.7 Supply Tanks, Over 500 Gallon Capacity, Installed Aboveground Outside

6.7.2 Every supply tank shall be diked where in the event of an escape of fuel, the fuel is likely to flow in a manner that would:

a) Create a hazard to public health or safety;

b) Contaminate any fresh water source or waterway;

c) Interfere with the rights of any person; or underground stream or drainage system.

6.7.3 The dike referred to in Clause 6.7.2 shall have dimensions that will ensure that the volume of liquid it will contain is equal to:

a) Where the dike contains a single tank, 100 per cent of the capacity of that tank

6.8 Filling of Supply Tanks

6.8.1 All supply tanks shall be provided with a fill opening or a fill pipe complying with Clause 8.2.1 or 8.2.2

6.8.2 Each fill opening and the entry to each fill pipe shall be provided with a tight metal cover designed to discourage tampering.

6.8.5 The entry to a fill pipe, required by Clause 6.8.4, shall be outside buildings and shall be located at an elevation lower than the termination of the vent pipe from the tank served by the fill pipe.

6.8.6 A fill pipe which has the entry to it adjacent to a building shall be installed sot that the entry shall be a point not less than 2 feet from any window intended to be opened or other building openings, or vertical projection of any window or building opening at a lower elevation than the entry to the fill pipe.

6.9 Venting of Supply Tanks

6.9.1 Each supply tank over 10 gallons capacity shall be provided with means for venting, complying with Clause 8.3 in regard to piping.

TABLE 3

MINIMUM DIAMETER OF VENT OPENING, VENT PIPE

Capacity of Tank, Gallon	Inside Minimum Diameter of Vent or Iron Pipe Size, Inch
500 or less	1¼
over 500 to 2,500	1½
over 2,500 to 8,500	2
over 8,500 to 16,600	2½
over 16,600 to 30,000	3

Note: Where tanks are filled by the use of a pump through tight connections, special consideration should be given to the size of the vent pipe to insure that it is adequate to prevent the development of abnormal pressure in the tank during filling.

6.9.4 The lower end of the vent pipe shall be connected:

a) At the top of the tank and shall not extend into the tank more than 1 inch;

b) To a vent alarm.

6.10 Gauging of Supply Tanks

6.10.1 All supply tanks, except oil tanks on which the fuel level is maintained by an automatic pump, shall be privided with means for determining the liquid level within the tank.

Note: On an outside supply tank, means may be by visual observation through the fill opening, by use of a measuring stick, or by use of an approved fuel level gauge.

6.10.2 Supply tanks installed inside a building shall be provided with an approved gauge

6.10.3 Gauging by means of a dip stick shall not be permitted inside a building.

8. FUEL OIL PUMPS, PIPING, TUBING, AND VALVES

8.2 Fuel Oil Pumps

8.2.2 The maximum pressure imposed on the inlet of a fuel oil pump shall be 5 psig unless the pump has been approved for a higher inlet pressure

8.2.3 The maximum lift, measured from the bottom of the supply tank, imposed on a fuel oil pump shall be 16 feet.

8.2.4 When the fuel oil pump is located above the supply tank, the pump and supply piping shall be installed to avoid air locks, and:

a) A two pipe system shall be used;

b) When the lift is above 8 feet, a two stage pump shall be used;

c) When the burner fuel oil pump is more than 16 feet above the bottom of the supply tank, an auxiliary pump shall be used. The auxiliary pump and controls shall be approved for the intended application.

8.3 Piping and Tubing

8.3.1 All piping and tubing, except as permitted by Clause 8.3.4 shall be new and be standard weight wrought iron, steel, or brass pipe; or brass, copper, or steel tubing; or the equivalent with respect to strength, durability, resistance to corrosion, and temperature.

8.3.3 Piping used in the installation of oil burning appliances shall not be smaller than 3/8-inch iron pipe size, or 3/8-inch (outside diameter) tubing having a wall thickness conforming to that specified in CSA Standard B140.0, General requirements for Oil Burning Equipment, except that 1/4-inch iron pipe size and 5/16-inch tubing may be used with burners having a firing rate of less than 1/2 U.S. gallon per hour.

8.3.8 Oil piping shall not be supported by any other piping but shall be installed with supports that shall not be spaced at greater distances than those shown in Table 6 and shall be of a sufficient strength and quality to support the piping.

TABLE 6

SPACINGS OF SUPPORTS

Pipe Size Inches	Spacing of Supports Feet
up to 1/2	6
3/4 to 1	8
1 1/4 to 2 1/2	10
3 to 4	15
5 to 8	20
Over 8	25
1 1/4 or larger	Also every floor level on vertical

8.3.11 Piping and tubing joints, and connections shall be made in accordance with the following:

a) Joints and connections shall be made fuel oil tight.

b) Joints and connections shall be made with standard pipe fittings or by welding.

c) Welded connections shall be made by a welder acceptable to the authority administering this Code.

Note: It is recommended that all concealed piping be welded wherever possible.

e) Unions requiring gaskets or packing, right and left couplings, and solder or brazing materials having a melting point less than 1,000 F shall not be used in connecting fuel oil lines.

8.4 Valves

8.4.1 A shut-off valve shall be installed in the fuel line in accordance with Clause 8.3.11 and as near as practicable to the exit from the supply tank and at such other locations as may be required to avoid spillage during servicing and shall be:

a) Of the manual type;

b) Readily accessible;

c) Installed to close against the supply of fuel oil; and

d) Of a type suitable for the intended service.

8.4.2 When a shut-off valve is installed in the return line from the fuel oil pump, a suitable pressure relief valve shall be installed in a return line and shall be:

a) Located in the return line between the pump and the shut-off valve; and

b) Arranged to:

(i) Return the surplus fuel oil to the supply tank; or

(ii) By-pass the surplus fuel oil around the pump.

APPENDIX A

AIR FOR COMBUSTION AND VENTILATION

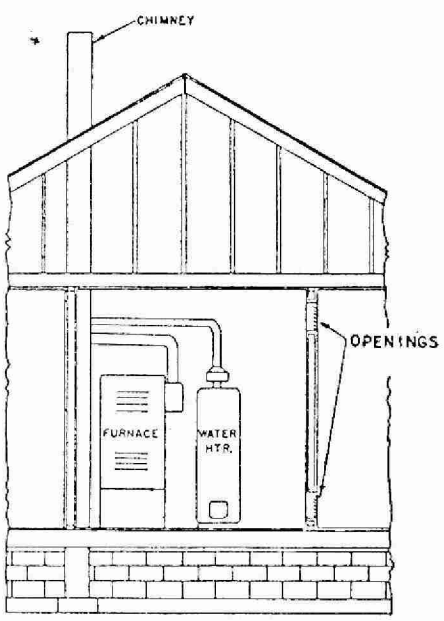


FIGURE A1

APPLIANCES LOCATED IN CONFINED SPACES, ALL AIR FROM INSIDE THE BUILDING

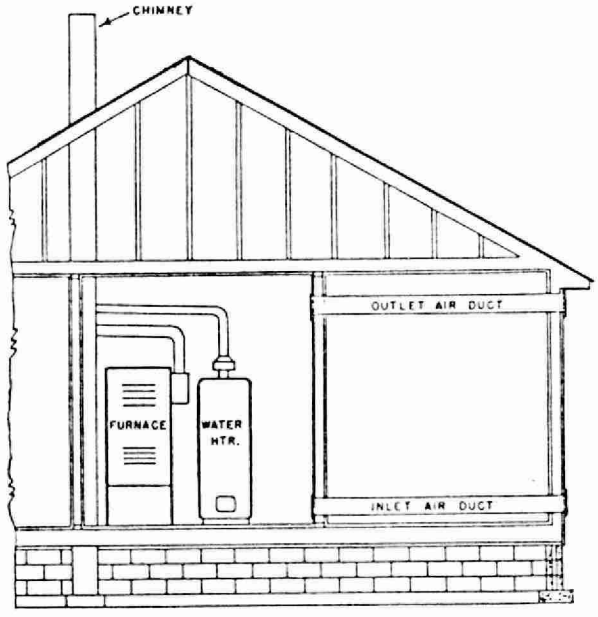


FIGURE A2

APPLIANCES LOCATED IN CONFINED SPACES,
ALL AIR FROM OUTDOORS

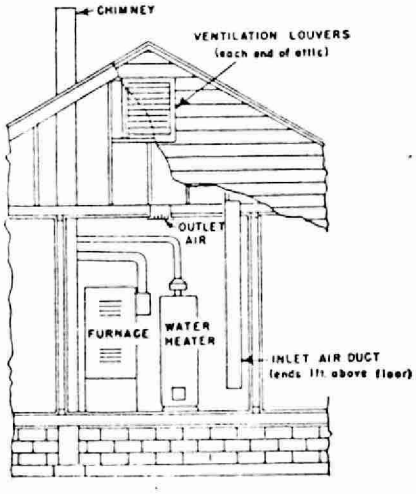


FIGURE A3

APPLIANCES LOCATED IN CONFINED SPACES,
ALL AIR FROM OUTDOORS THROUGH VENTILATED ATTIC

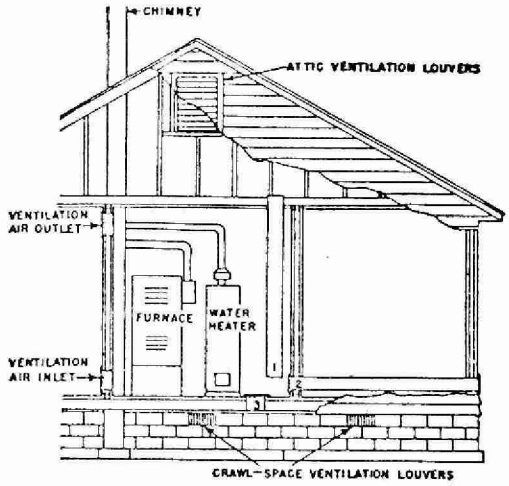


FIGURE A4

APPLIANCES LOCATED IN CONFINED SPACES,
AIR FROM INSIDE BUILDING —
COMBUSTION AIR FROM OUTSIDE, VENTILATED
ATTIC OR VENTILATED CRAWL SPACE

NOTES: *1. Ducts used for make-up air may be connected to the cold air return of the heating system only if they connect directly to outdoor air.*

2. Attic ventilation louvres are required at each end of the attic with alternate air inlet No. (1).
Nos. (1), (2), and (3) indicate alternate locations for air from outdoors.

3. Crawl-space ventilation louvres for unheated crawl spaces are required with alternate air inlet No. (3).

FIGURE A4

APPLIANCES LOCATED IN CONFINED SPACES,
AIR FROM INSIDE BUILDING -
COMBUSTION AIR FROM OUTSIDE, VENTILATED
ATTIC OR VENTILATED CRAWL SPACE

APPENDIX B

INFORMATION CONCERNING THE SUITABILITY OF MASONRY OR CONCRETE CHIMNEYS AND FLUES (REFER TO CLAUSE 4.2.2)

TABLE B1

RECOMMENDED DIMENSIONS FOR CHIMNEY FLUES

Total Rated Input GPH (U.S.)	Minimum Size of Rectangular Tile Liner Nominal Inches		Height of Chimney Above the Flue Pipe Entry Feet
	Outside	Inside	
Up to 0.75	8 x 8	6.75 x 6.75	15
Over 0.75 to 1.25	8 x 8	6.75 x 6.75	20
Over 1.25 to 2.00	8 x 8	6.75 x 6.75	25
Over 2.00 to 3.00	8 x 12	6.75 x 9.75	25
Over 3.00 to 4.50	12 x 12	9.75 x 9.75	30

NOTES: 1. *Sizes shown in Table B1 are for average conditions. Exact requirements should take into consideration the type of appliance, chimney height, flue gas temperature, and the required draft. For example, a higher chimney may permit reduction in the cross-sectional area.*
2. *When rated output capacity exceeds that shown in the Table, the manufacturer's recommendations should be followed.*
3. *Actual inside dimensions of the tile liner are usually less than the nominal.*
4. *For two or more appliances, the total input should be totalled.*

FIGURE B1

ANALYSIS OF CHIMNEY FAULTS

Symbol	Trouble	Disclosed by	Remedy
A	Top of Chimney Lower than Building	Observation	Extend Chimney (See Figure 1)
B	Chimney Cap or Ventilator	Observation	Remove
C	Coping Restricts Opening	Measurement	Make Opening Equal to Inside of Chimney
D	Broken Tile Wedged in Chimney	Lowering Light or Weight Down Chimney	Break Tile with Weight on Wire or String
E	Birds Nests	Observation	Remove
F	Joists Protruding into Chimney	Lowering Light or Weight Down Chimney	Remove Projecting Portion to Clear Chimney
G	Leakage Between Loose Jointed Tile	Smoke Test with Top of Chimney Closed	Rebuild Chimney with Course of Brick between Tiles
H	Debris Accumulated in Offset	Lowering Light or Weight Down Chimney	Break Out with Rod or Weight
J	Unused Flue or Vent Connection	Observation	Remove
K	Smoke Pipe Extends into Chimney	Lowering Light or Weight into Chimney	Make End Flush with inside of Chimney
L	Offset	By Lowering Light or Weight Down Chimney	Change to Straight or Long Offset
M	Loose Fitted Smoke Pipe	Smoke Test	Close Leaks with Cement
N	Loose Fitted Cleanout Door	Smoke Test	Close Leaks with Cement
O	Opennig between Flues	Smoke Test	Close Openings Permanently
P	Chimney Too Small Chimney Too Large Chimney Too Short	Measurement Measurement Measurement	Rebuild Rebuild Extend or Rebuild

CHARACTERISTICS OF GAS FUELS

GAS	HEAT VALUE BTU/FT^3	SPECIFIC GRAVITY or VAPOUR DENSITY	EXPLOSIVE LIMITS IN AIR BY VOLUME		THEORETICAL AIR REQUIRED FOR COMPLETE COMBUSTION	MINIMUM IGNITION TEMPERATURE	MAXIMUM FLAME TEMPERATURE	FLAME SPEED PER SECOND	AUTO IGNITION TEMPERATURE
			LOWER	UPPER					
METHANE	913.1	0.55	5	15	9.56 to 1	1170°F (632°C)	3484°F (1918°C)	0.85	1000°F (538°C)
NATURAL GAS	1027	0.6	4.9	15	10.00 to 1	1170°F (632°C)	3562°F (1961°C)	0.99	1000°F (538°C)
PROPANE	2385	1.52	2.10	10.10	23.9 to 1	898°F (481°C)	3573°F (1967°C)	0.95	871°F (466°C)
DIGESTER GAS	500-800	Variable*	5.7	13.5	Variable*	-	-	-	-
FUEL OIL NO. 2	18,190-19,810**	.898			74.6 to 1	494°F (257°C)	2600°F (1427°C)	NA	800°F (427°C)

* Quality of gas varies with content of impurities

** Heat value is btu per lb. of fuel oil

SUBJECT:

COMBUSTION

TOPIC: 5

PRINCIPLES OF COMBUSTION

OBJECTIVES:

The trainee will be able to:

1. Outline the three conditions that must be maintained in a furnace - the "three T's of combustion";
2. State why excess air is used;
3. List the methods used to increase the effect of the "three T's of combustion";
4. Describe how soot and smoke are formed;
5. List four conditions which should be looked for if a furnace produces smoke.

PRINCIPLES OF COMBUSTION

GENERAL

Combustion is the rapid high temperature oxidation of fuels. Since most fuels used at present consist almost entirely of carbon and hydrogen, burning involves the rapid oxidation of carbon to carbon dioxide or carbon monoxide, and of hydrogen to to water vapour. The following overall reactions occur:

$$C + O_2 \longrightarrow CO_2 + Q$$

where Q = 14,093 BTU/lb carbon

$$2H_2 + O_2 \longrightarrow 2H_2O + Q$$

where Q = 61,000 BTU/lb hydrogen.

In practical cases the fuel is not pure hydrogen or carbon, but is combined into gases such as methane or propane, complex hydrocarbon mixtures as liquids, and solid and tarry materials in solid fuels. Mineral ash, sulphur and trace metals may be combined with the fuels, and will produce a wide range of contaminants. The oxygen required for combustion is normally supplied in air, which contains approximately 79% nitrogen by volume. Although nitrogen is normally considered inert, this gas can react with oxygen at high temperatures to produce oxides of nitrogen, a significant air contaminant.

The basic requirements for practical gas phase combustion are:

1. A point source of high energy output.
2. A flammable mixture of combustible gases and air.
3. Thorough mixing at the point of ignition and flame propagation.
4. A carefully designed flame holder.
5. Provision of space for burnout.
6. A heat sink.
7. Removal of combustion products from the reaction zone.

3Ts of Combustion

Temperature, Turbulence and Time, the classic 3Ts of combustion, are widely quoted but frequently misunderstood.

Temperature

The flammable gas mixture must be raised to its threshold ignition temperature. Heat must be available to ensure auto-ignition. This heat may come from an ignitor, from recirculated fuel gas or from flame radiation. A high temperature is also required to maintain burnout of the reactants.

Ignition energy can be supplied electrically with a high tension arc or spark or with a combination spark fuel ignitor. Once the fuel is ignited and a stable flame is established, radiation from the flame or hot recirculated gas may be enough to maintain ignition of raw fuel. With solid fuel beds the incoming fuel is usually ignited by contact with the hot fuel bed.

Temperature downstream of the fuel air mixing zone can be maintained by proper design of any heat exchanger which may be integral with the combustion equipment, or by controlling the rate of withdrawal of combustion products. The physical size, configuration and material of construction of any enclosure are important considerations. The ability to absorb and/or re-radiate the heat released will significantly affect the bulk gas temperature.

Turbulence

Thorough mixing is required at the point of ignition and the propagation zone to ensure that sufficient successful collisions occur between reactants to initiate and propagate the combustion reaction. Once active ions are in contact, mixing is not essential. This mixing can be achieved by physical means or aerodynamic means.

The common "physical means" are the employment of bluff bodies or baffles judiciously arranged to change the direction of the fuel air stream in a manner that promotes thorough mixing; in some cases vigorous back-mixing is promoted, and standing vortices are formed.

The combustion air can be introduced in patterns which cause violent radial and tangential motion of the fuel-air stream, and increase the possibility of successful collisions between the reactants. This is accomplished by introducing the air through orifices, annuli, and slots at high velocity. In solid fuel burning, it may be necessary to introduce air above the bed to promote combustion of volatile material and intermediate compounds produced in the bed. In modern burner applications, the air may be introduced to provide a two stage combustion effect. The first stage is proportioned to be fuel rich and the second to be oxygen rich. This provides optimum conditions for maximum fuel burnout with fewer side reactions.

Time

Time is required to complete the reaction downstream of the zone of ignition and flame propagation.

The initiation and propagation stages of the combustion reaction occur in a matter of milliseconds. The final stage of the reaction requires some finite time, which is temperature and concentration dependent, and varies with molecular structure.

The time required for complete combustion of a given material can be determined theoretically. This theoretical time is based upon perfect mixing i.e. a maximum collision frequency in the reaction mixture. In practical systems, mixing is imperfect and the conditions for optimum propagation are not always obtainable. Practical combustion systems require conservative sizing of the enclosure in order to ensure that combustion is virtually complete in the gaseous phase.

Air in Combustion

The large majority of combustion systems use air as the source of oxygen for the combustion reaction, because

1. It is readily available and cost is limited to the equipment and energy required to pump it into position.

2. It contains a natural diluent, nitrogen, which is a useful heat sink or energy acceptor and product gas diluent. This aids in moving the combustion reaction toward completion.

3. The total mass of air exceeds the mass of oxygen required by roughly 3.3/1; this extra mass is useful for generating mixing momentum.

4. By acting as a heat sink it reduces flame temperatures and prevents destruction of the enclosure.

5. A combustion reaction can be moved closer to completion by having excess of one reagent present. Oxygen carried in air is the most practical excess reagent to supply.

There are certain disadvantages:

1. Improperly mixed or directed excess air inhibits the combustion process by chilling the propagation reaction and breaking the reaction chain. Frequently unburned fuel or carbon may be emitted as a result.

2. Nitrogen can react with oxygen at high temperature to produce oxides of nitrogen; when excess oxygen is present, oxides of nitrogen will be formed and emitted.

3. If a fuel contains sulphur, and excess oxygen is available, some of the sulphur dioxide produced will be oxidized to sulphur trioxide. The sulphur trioxide combined with water vapour produces sulphuric acid, which can be absorbed on any carbon deposits in the system if the temperature drops to dewpoint. The resulting acid smut can corrode the combustion system or be discharged to the atmosphere to cause soiling and corrosion.

Practical combustion systems operate with excess air, the variation of excess air with load depending upon combustor design and the air-fuel ratio control system fitted to the combustion system. Some modern boilers operate at 3 to 5% excess air when firing oil or gas. Most contemporary systems operate at 15 to 50% excess air.

Smoke is a highly visible cloud of particles which is persistent in nature i.e., does not readily dissipate. These particles are usually finely subdivided and produce the light scattering phenomenon which registers on the human eye as a visible plume. The particles may be carbon, unburnt hydrocarbon, or mineral ash.

The common black or grey smoke is produced by fine carbon particles which result when a reacting fuel air mixture is chilled - by contact with a cold surface or by tramp air. Fine carbon particles are formed which are carried out of the system as smoke. If sufficient cool surface is present these particles will deposit on the surfaces of the combustion system as soot. Starving the system of air will cause fuel cracking or pyrolysis and the same phenomenon will result.

If a furnace is producing smoke, one or more of the following four conditions may exist:

a. Insufficient air to burn the fuel
b. Too much air, which chills the flame rapidly
c. Insufficient or improper mixing of the air or fuel
d. Cold surfaces or admission of tramp air to the system.

The most common visible emissions from combustion systems are:

Black or grey - carbon particles
Persistent blue white - hydrocarbon
Brown to grey - fly ash
Dissipating white - condensed water vapour.

SUBJECT:

COMBUSTION

TOPIC: 6

BURNERS AND BURNER CONTROLS

OBJECTIVES:

The trainee will be able to:-

1. State the function of a burner
2. Recall the three ways fuel oil is atomized
3. Explain, using a schematic diagram, the operation of a high pressure oil burner
4. Set the electrodes of a high pressure oil burner
5. Clean the air nozzle of a high pressure oil burner
6. Differentiate between Atmospheric Forced Draft and Induced Draft Burners
7. Recall the operation of
   a. Protector Relays
   b. A Flame Failure Device

BURNERS AND BURNER CONTROLS

GENERAL

In a WPCP three types of fuel, #2 furnace oil, natural gas and digester gas, may be used. The burners which heat the boilers can fire on oil, gas or a combination of both. Nevertheless, every burner does the same thing. It proportions the fuel and the air and mixes them in preparation for burning.

OIL BURNERS

Since all fuels burn as a vapour, the liquid oil must either be converted to a gas in the burner (vaporized) or divided into such small particles or droplets (atomized) that radiated heat will vaporize within the burner. If the temperature of the flame is too low, incomplete combustion and smoke emission will result. Cooling of the flame can occur when the combustion chamber is too small, resulting in flame impingement, or too large.

Oil droplets burn at the surface. The droplet shrinks in a manner analogous to peeling an onion, so it is necessary for turbulence to provide sufficient air to complete the combustion of each successive layer. Consequently, it is important to mix the air and oil.

Vaporizing burners gasify the oil by heating it within the burner. These burners are limited in the range of fuels they can handle and are used only for some residential furnaces and water heaters.

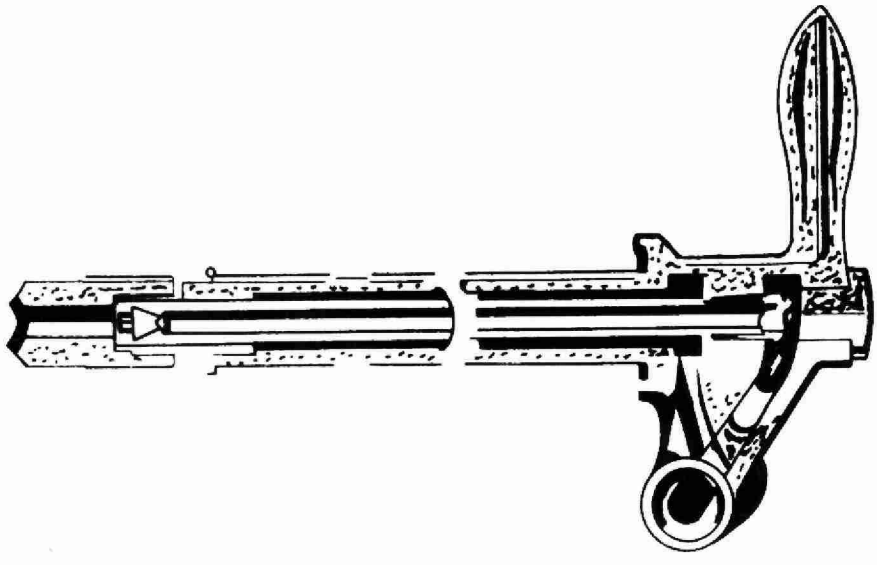


Figure 6-1 Steam-Assisted Pressure Atomizer

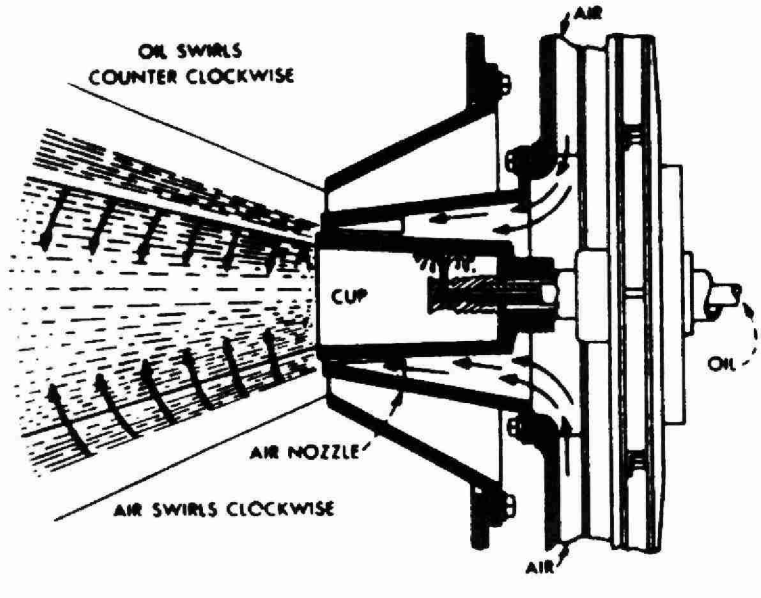


Figure 6-2 Horizontal Rotary Cup Burner

Atomizing of fuel oil can be accomplished in three ways:

1. Using steam or air under pressure to break the oil into droplets. (Figure 6-1)
2. Tearing the oil film into drops by centrifugal force. (Figure 6-2)
3. Forcing oil under pressure through a nozzle. (Figure 6-3)

All three methods are used in burners. However, in a WPCP burners shown in Figures 6-1 and 6-2 are seldom if ever used.

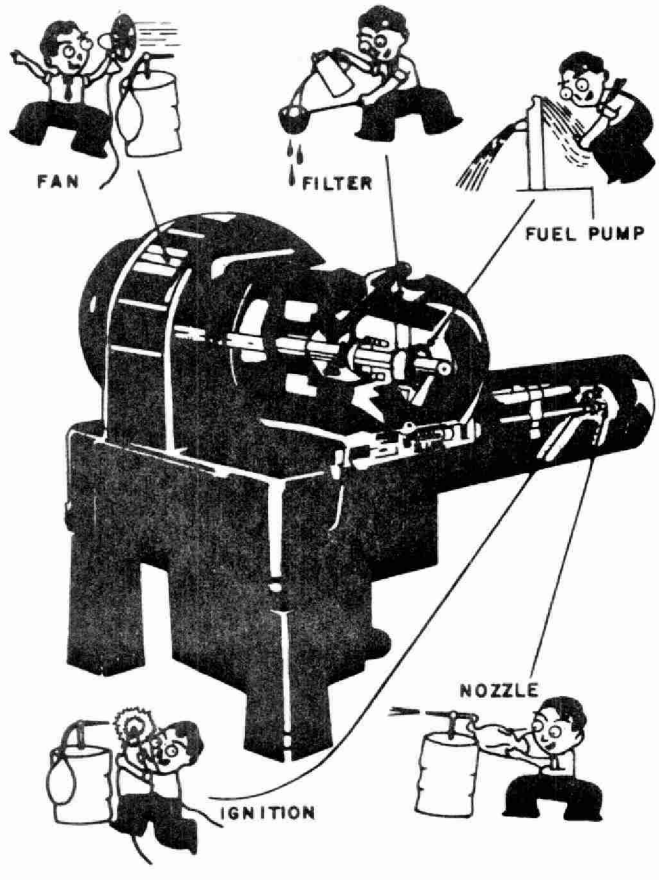


Figure 6-3 High Pressure Oil Burner

HIGH PRESSURE BURNER

A schematic diagram of a high pressure burner is shown as Figure 6-4.

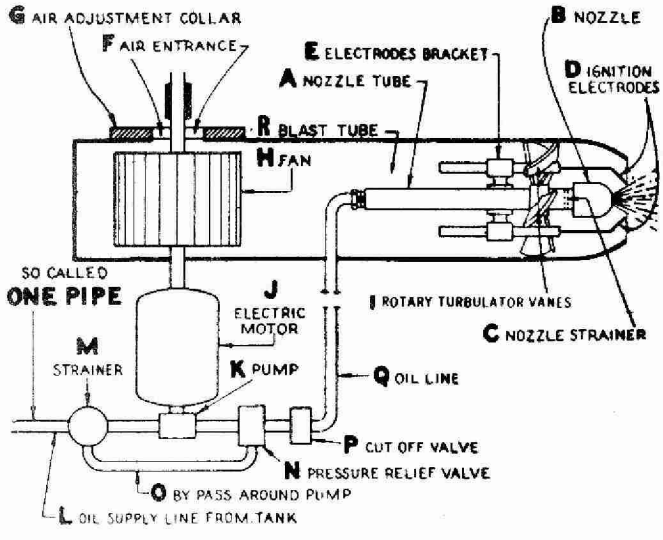


Figure 6-4 Schematic Diagram
High Pressure Oil Burner

The electrical parts of the burner which are attached to the housing and built into the unit are:

1. The electric motor
2. The transformer
3. High tension leads
4. Electrodes

The motor runs the forced draft fan and usually the oil pump. The latter is sometimes a separate unit with its own motor. Forced draft means that the air for combustion is pushed into the boiler by a fan. This is different from "induced draft", where a fan is placed in the stack and actually sucks the air for combustion through the whole boiler. This type of fan is not too often used because it is much larger than a "forced draft" fan and uses more power.

The ignition transformer supplies high voltage for ignition. It draws either one of 110/220 V and delivers 10,000 volts. The high tension leads fulfill the same function as the ignition or spark plug wires in a car. It leads the high current to the electrode.

The electrodes fulfill the same function as a spark plug, namely providing the spark for ignition, and the setting is very important for proper ignition. A rule of thumb for electrode setting is 1/8" - 3/16" apart, 3/8" - 1/2" ahead of the nozzle and about 3/8" - 1/2" above the centre of the nozzle (see Figure 6-5). The electrodes should not be touched by the oil spray, but should be about 1/32" away from it. Always follow the manufacturer's instructions on exact measurements for electrode setting.

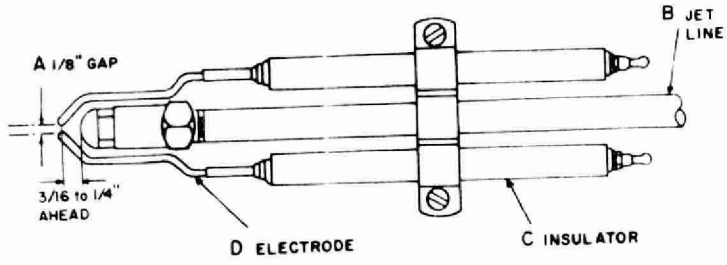
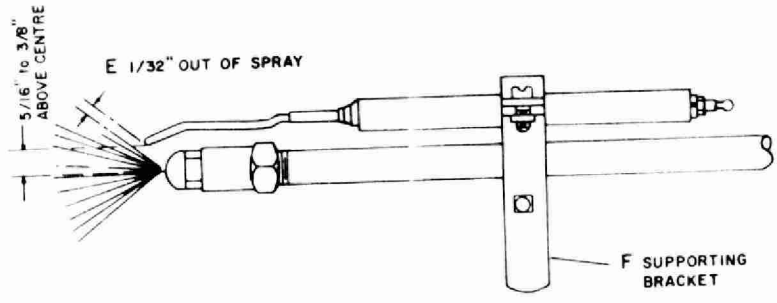


Figure 6-5
Electrode Setting



The "forced draft" fan (H) delivers the air for combustion through the blast tube (R), through the turbulator (I), which gives the air a swirling motion, to the front of the burner. The air is drawn into the back end of the burner through adjustable air shutters (G). The fuel pump (K) brings the oil up from the tank and pushes it through the delivery tube (A) to the nozzle (B).

The pump delivers the oil under a high pressure, of between 150 - 200 P.S.I. An internal or external bypass (N, 0) arrangement brings the nozzle pressure back to 100 P.S.I. All nozzles are rated for this pressure.

AIR NOZZLES

A nozzle is a finely machined piece of equipment in itself, and should always be treated with the utmost care. Never use any coarse materials such as wire brushes or steel wool to clean any internal or external parts. If this seems necessary, discard it and buy a new one. Even the smallest minute scratches in the oil passages can throw out the spray pattern and result in a poor fire.

The nozzle has six (6) main parts. See Figure 6-6

1. Nozzle tip (E)
2. Distributor (B)
3. Screw pin (F)
4. Strainer body (G)
5. Strainer screen (C)
6. Adapter (H)

Oil delivered by the pump to the nozzle enters the filter screen (C) and is forced through the slots in the distributor (B) into the swirling chamber (D). The slots give the oil a swirling motion. From here it is forced through the orifice (A) with high velocity into the combustion chamber, which it enters as a fine mist.

Just at the front of the nozzle the air is brought in contact with the oil and this air has also a swirling motion in opposite direction of the oil. The result is a thoroughly mixed mixture of air and oil which will easily ignite the moment that the spark is applied.

The chamber on the orifice denotes the spray angle of the nozzle which may be anywhere from 15° to 90°. The diameter of the orifice itself determines the size of the nozzle.

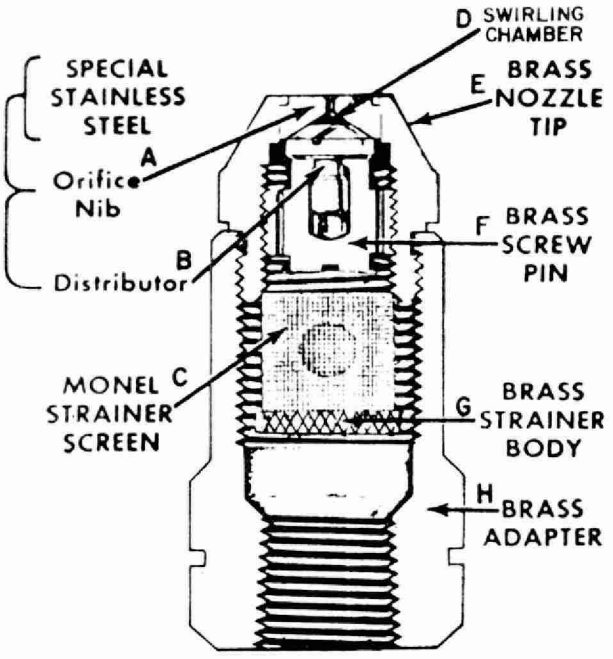


Figure 6-6 HIGH PRESSURE GUN FUEL NOZZLE

All nozzles are rated in U.S. gallons per hour. When you see 5.00 - 30° stamped on the side of the nozzle it means the nozzle is rated at 5 U.S. gallons per hour and has a spray angle of 30° at 100 P.S.I. Always use the size of the nozzle specified for your particular boiler. If you use a smaller size you will not be able to get the maximum heat out of your boiler. If you use a larger size, there is danger that sufficient air will not be available for combustion, and improper firing will result. There is some flexibility in the oil pressure, if just a little more heat is required. The oil pressure may be boosted to 125 P.S.I. which will give more oil, but do not go below 100 P.S.I. because this results in poor mixing with the air.

To clean a nozzle, soak it in a solvent such as Varsol or another of the types commercially sold. If you feel it needs further cleaning in the small passages use a wooden toothpick. Sometimes new nozzles have dried oil in the passages which alter the pattern; clean them in the above manner.

GAS BURNERS

A gas burner is a relatively simple burner. It is usually a hollow ring or bar with a series of small holes. The gas is applied to the burner under a pressure varying from 2" water column to 40" water column. The burner is connected to the gas main line and the gas escapes through the holes. Usually in WPCP boilers, the burner is set right in the air stream and the gas and air mixes to form the proper combustible mixture.

There are three types of gas burners and they are classified by the way the air is supplied.

1. Atmospheric or Domestic Burners
2. Forced Draft Burners Figure 6-7
3. Induced Draft Burners

With any burner however, both air and gas should be separately adjustable for proper mixture regulation.

Atmospheric Burner

This type of burner is mostly found in domestic applications, such as hot water heaters, hot air furnaces, gas stoves, etc. The flow of gas sucks in air through an adjustable orifice and forms the combustible mixture inside the burner. This mixture escapes through the little holes and burns right above the burner.

Forced Draft Burner

This type of burner Figure 6-7 is mounted in the air stream. The air is supplied by an external fan much the same as in the oil burner. The gas and air are therefore mixed outside the burner and burn in the combustion chamber.

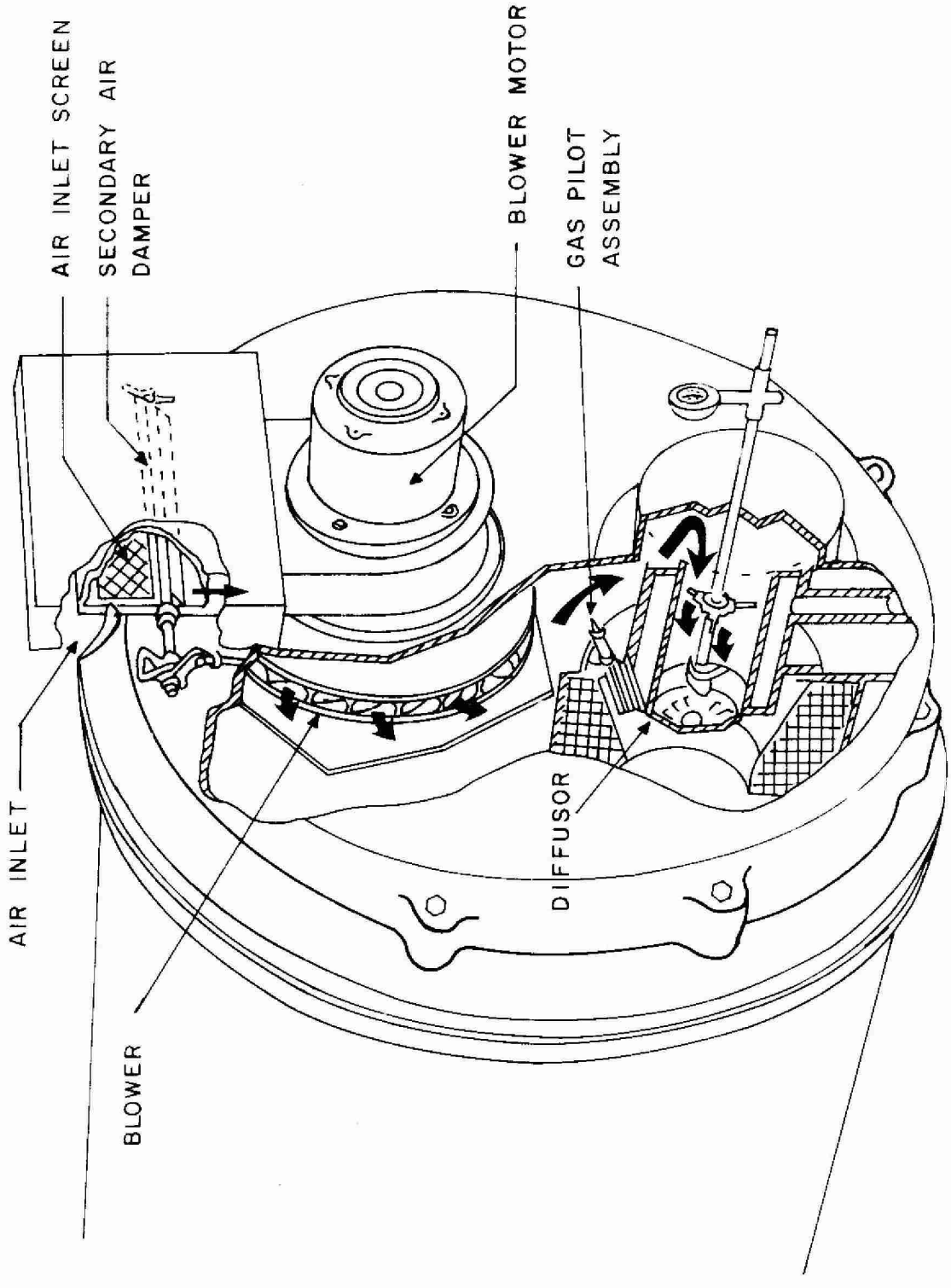


Figure 6-7 FORCED DRAFT BURNER

Induced Draft Burners

The burner is mounted in the air stream the same as with the forced draft burner. The only difference is that the air is drawn through the boiler by a fan mounted in the stack. The air is drawn in through adjustable openings in front of the boiler.

COMMERCIAL AND INDUSTRIAL PILOTS

In commercial and industrial applications where natural gas is burned, the pilot is a natural gas pilot. This is a small line with its own valve train taken from the main gas line ahead of the main gas valve train. This pilot is ignited by an electric spark from an electrode much the same as was discussed in the oil burner section. This pilot may be an interrupted or a constant pilot. The difference between the two is that the interrupted pilot goes out after the main flame is established and a constant pilot burns as long as the main flame is on. It is only turned off manually.

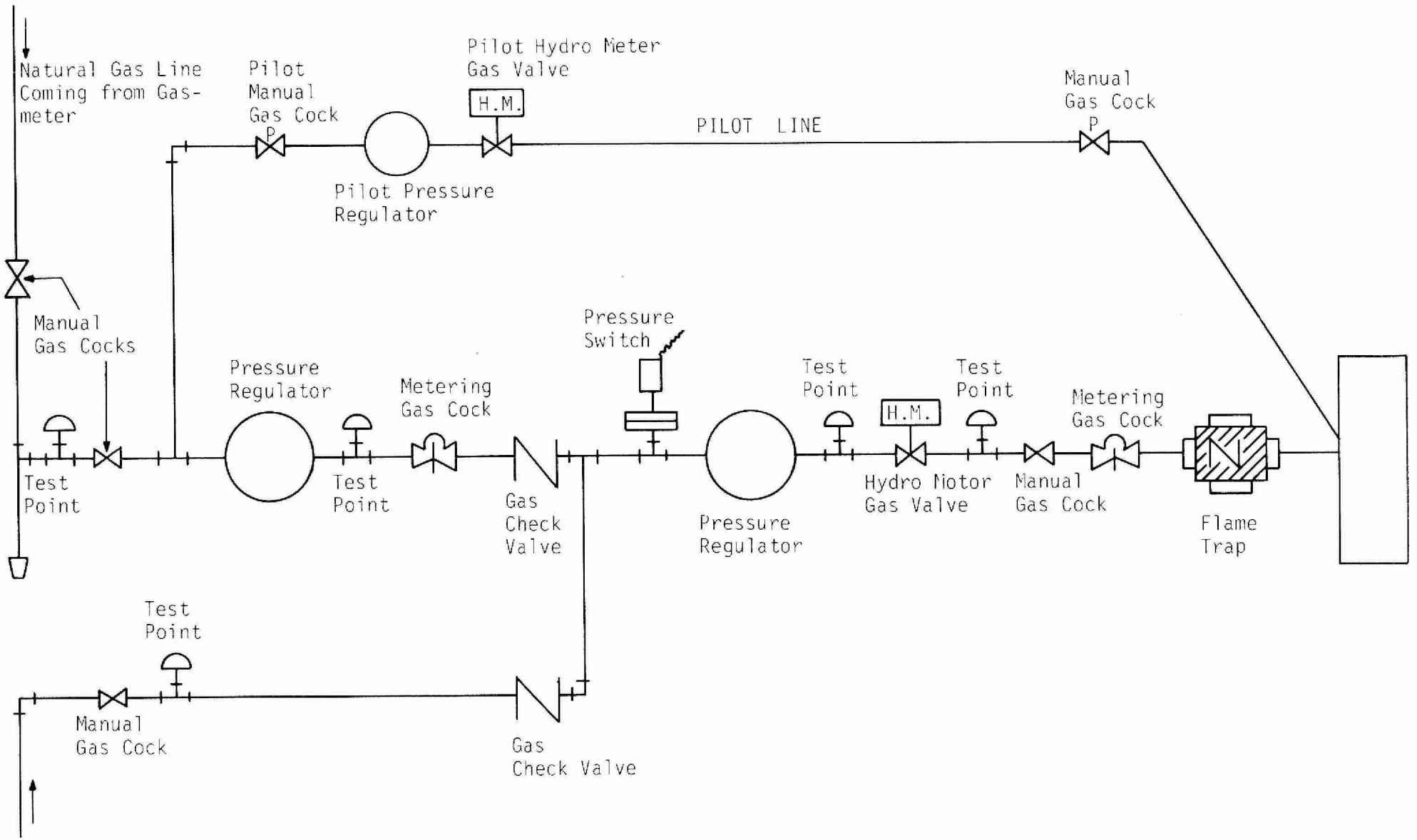
In digester gas fired burners, if a combination natural gas/digester gas is used, the pilot may be a natural gas pilot or a propane gas pilot. If the combination is oil/digester gas, the pilot must be propane gas, which is obtained from an external source.

GAS VALVE TRAIN

Regulations now require a somewhat sophisticated gas valve train as a safety measure to protect against the hazards involved in burning a gas fuel. Figure 6-8 is a schematic of a gas train for a boiler burning natural and digester gas. Other combinations of fuels for different applications will vary.

FIG. 6 - 8

SIMPLE SCHEMATIC FOR A DUAL GAS VALVE TRAIN



BURNER CONTROLS

There are different types of control relays on the market but basically they all perform the same function. They program the complete cycle through which the electrical cycle of the boiler has to go through, and if for any reasons a safety device such as low water cut off or flame failure device should operate, this control relay will drop out. Fig. 6-9 shows what happens during the operating cycle of the protector relay.

When the boiler calls for heat, the programming timer motor is energized, starting at the same time as the burner fan. After a pre purge period of 25 seconds the ignition will start; 5 seconds later the gas pilot will open only if spark ignition is established. 15 seconds after the pilot valve opens, ignition is shut off, pilot flame stays on and main gas valve opens. With flame established this valve stays open until heat is no longer required. At this time the timer starts up again for a 15 second post purge period after which all circuits open and the fan stops.

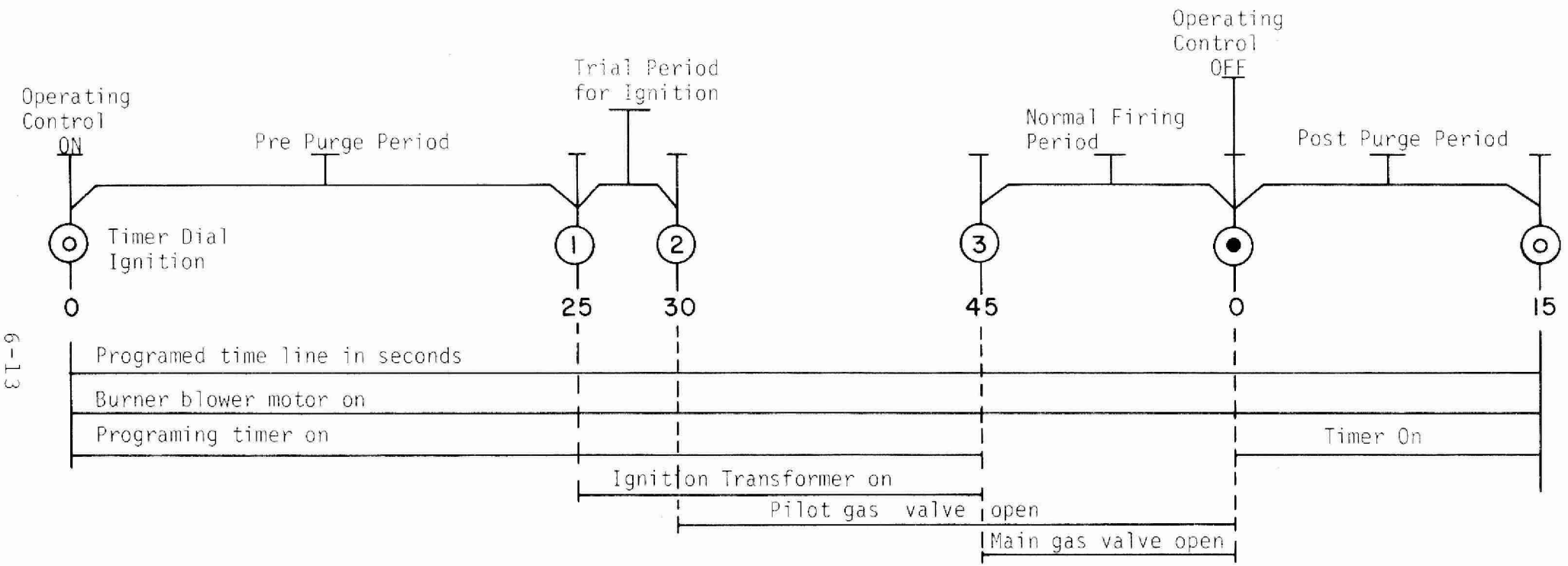
FLAME FAILURE

Each boiler must have a flame failure device. This can be the flame rod type whereby the flame envelops a metal rod. The action of the flame sets up a mini-current in this rod which is wired into the circuit and keeps the circuit closed. The moment the flame fails the mini-current is broken and within 90 seconds the electrical circuit opens, shutting down the burner.

An ultra violet scanner is another type of flame failure device. This is an electronic eye which sees the ultra violet rays of the flame, again this causes a mini-current to flow into the circuit keeping the circuit closed and on flame failure shutting the burner down.

FIG. 6 - 9

FIREYE PROGRAMMING SEQUENCE WITH INTERRUPTED SPARK IGNITION



The device is a safety device. If for any reason the flame failed and such a device was not in use, oil or gas could pour into the combustion chamber and be accidently ignited by a hot spark off the brickwork. This could cause an explosion and result in extensive damage to the boiler. The flame failure device prevents this.

The flame failure device should be checked monthly by simulating flame failure. Shut off the fuel supply and check to see if the burner shuts down within 90 seconds.

Attached as Appendix A are extracts of draft Code CGA B105 Installation Code for Digester Gas Systems which refer to Boilers, Burners and Burner Controls.

EXTRACTS

DRAFT CODE CGA B105

Installation Code For Digester Gas Systems

12 BOILERS

12.1 Natural gas, digester gas, propane and oil fired boilers and any such fuel combination fired separately or in combination shall be approved by the enforcing authorities for the application and shall have affixed an acceptable approval label indicating compliance with Standard(s) authorized for use by the enforcing authority.

12.2 Natural gas, digester gas, propane and oil fired boilers shall be installed in a separate room or building or other location isolated from but as close as is practicable to the digester control, room or building and source of digester gas supply.

12.3 A boiler room(s) adjacent to the digester control room shall have separation walls of gas tight construction. All communicating piping and conduit entrance sleeves through the separation walls between the digester control room and the boiler room shall be gas tight, and there shall be no communicating door or window openings in the separation walls (s).

12.5 Boiler Vent Stacks

12.5.1 The boiler vent stack termination shall be not less than 15 m linearly from the perimeter of any digester.

12.5.2 Boiler Vent Stacks may be located so that their termination is not less than 7.5 m from any other Boiler Vent Stack termination or any Waste Gas Flare Stack termination.

13 BURNER CONTROLS

13.1 For burner controls and safety devices including venting refer to Part II Schematic Valve and Control Train Arrangement Diagrams Figure 37 Series as outlined for gas to gas and gas to oil firing.

13.2 For oil firing control and valve train arrangements refer to the current code CSA B139 INSTALLATION CODE FOR OIL BURNING EQUIPMENT.

14 GAS PILOTS OTHER THAN FOR WASTE GAS BURNERS

14.1 Where a burner uses a pilot there shall be provided a natural gas or propane pilot. (Refer to Part II Schematic Diagrams Figure 37 Series).

14.2 Where digester gas is used either natural gas or propane shall be provided as an auxillary fuel for pilot burners and a three way manually operated plug or ball valve shall be provided. (Refer to Part 11 Schematic Valve and Control Train Arrangement Diagrams Figure 37 Series).

15.2 Ignition Systems

15.2.1 Only a natural gas or propane fired pilot shall be provided and the pilot flame shall be proven to an annunciator.

15.2.2 Electrical ignition may be used to ignite the pilot burner or the waste gas burner. The transformer, timing unit and other control components shall be in a protective housing in a location free from corrosive atmospheres and where the ambient temperature and humidity are within the tolerances specified by the manufacturer. Components shall be such that the energy

release at the point of ignition shall be adequate to reliably ignite the waste gas burners and the transformer shall not be rated at less than 6000 V and 20 Ma.

SUBJECT:

DIGESTER GAS DISTRIBUTION

TOPIC: 7

Safety

OBJECTIVES:

The trainee will be able to:-

1. List the hazardous areas associated with digester gas production and distribution
2. Recall the requirements for venting and air circulation in hazardous areas
3. Carry out a test for combustible gases using a combustible gas analyzer
4. List the basic rules for entry into a confined space
5. Carry out or describe the safety procedure to be followed when repairing
    a. Equipment on the digester
    b. Mechanical mixers
6. Recall the safety requirements for welding and for electrical apparatus and equipment.

SAFETY

GENERAL

The digester and digester gas distribution system are potentially among the most dangerous areas in a wastewater treatment plant. Those working in these areas must be thoroughly familiar with the potential hazards, the safety devices that should be used, the precautions to take and the general rules for working safely. A good inspection and maintenance program in the digester(s), the gas system and safety devices in the distribution system combined with personal hygiene, safety equipment and application of safe working procedures will significantly reduce, if not eliminate, the likelihood of dangerous conditions developing.

Each job will have special problems which require thinking ahead about safety of individuals and equipment used on the job. Necessary safety consideration must also be included with the list of materials, equipment and procedures which are developed for the job.

BODY INFECTION

Workers in treatment plants are exposed to the hazards of water-borne diseases, including Typhoid Fever, Amoebic Dysentery, Infectious Jaundice and other intestinal infections. Tetanus and skin infections must also be guarded against.

A majority of infections reach the body by way of the mouth, nose, eyes and ears. Therefore, washing your hands is a must before eating or smoking. Wear protection gloves where possible.

Soap preparations requiring no water rinse are available for field use. The common drinking cup should be banned, each man should have and use his own.

Typhoid and Tetanus innoculations are recommended. These may be obtained free of charge from local Health Authority.

This hazard to plant personnel although very real and ever present can be largely reduced by the individual himself by following a few basic rules of personal hygiene. A few of these self applied rules are attached as Appendix A.

PHYSICAL INJURIES - First Aid

Except for minor injuries, wounds should be treated by a doctor and reported for possible Workman's Compensation. Service truck and plant personnel should receive first aid instruction. See Appendix B.

It is a "Compensation Board" regulation that any plant having five(5) or more people working as a group on any shift, one of them is required to hold a valid First Aid Certificate. Remember, no cut or scratch is too minor to receive attention.

GENERAL PLANT SAFETY

The following are NO SMOKING areas in a WPCP:-

1. Influent buildings
2. Detritor rooms
3. Wet and dry wells of plant pumping stations
4. Pump rooms containing raw sludge pumps
5. Tunnels having pipe galleries carrying digester or natural gas pipe
6. Digester, digester control buildings
7. Sewers, manholes
8. Sludge holding tanks (covered)
9. Near sludge thickening tanks while mixing with compressed air is underway.
10. Sludge conditioning tanks in filter rooms
11. Sludge loading pipes to trucks
12. Sludge discharge pipes to drying beds
13. Chemical rooms

Some Protective Safety Equipment

The need for protective safety equipment in an accident prevention program has proven its value many times;

the program cannot be successful if any phase of accident prevention is overlooked.

Use safety equipment as it was meant to be used. This should be compulsory during the performance of hazardous jobs.

Protect eyes and face when there is any possibility of injuries from hand tools, power tools, welding equipment, etc.

Protect feet with safety shoes to safeguard against injuries while breaking pavements, tamping trenches, handling materials, etc.

Protect head (with hard hats) to prevent serious injuries in construction, excavation or electrical work.

Protect hands (with gloves) to prevent injuries from occurring when handling materials, sharp objects, chemicals or electrical equipment.

Use air packs when hazards such as chlorine, painting or dusty areas exist.

Prevent accidents due to falls by using safety belts, scaffolds, etc.

When working at the plant, observe the following common sense rules:

Keep walkways clear of loose objects such as pails, shovels, loose rope, etc.

Wipe up grease and oil *immediately;* salt or sand icy walks.

Pick up all tools, clean them and return them to their storage area.

When it is necessary to use tools in an empty tank or manhole, etc., lower them in a pail on a rope and remove them in the same way. Brooms and shovels can also be transported by rope. *Do not attempt to climb up and down ladders with your hands full of tools.*

Do not overload yourself when using stairways. Keep your load small enough to be able to see over it. Always keep one hand free to use the hand-rail.

Do not try to climb up or down a ladder or over a railing when handling a hose under pressure.

Always wear rubber or plastic coated, waterproof gloves when cleaning pumps, handling hoses, removing grit or sludge, etc.

When it is necessary to use an extension ladder *always lash the ladder to a hand-rail.*

Always wear hard hats when working below ground level (in tanks, manholes, etc.) or under scaffolding.

Do not hang clothes on electrical disconnect handles, light switches or control panel knobs.

Always wear a safety belt with a short rope and a safety snap when leaning out through the railings over any tank (or cleaning out spray nozzles, etc.)

Be very careful during repair work on fuel systems of gasoline engines. *Close the shutoff valve* from the tank and *be sure there is adequate ventilation* while draining the fuel system.

Tools and Machines

Use protective equipment when operating power equipment if there is any chance of flying objects or other injuries. Inspect all tools and equipment for safe operation. Necessary repairs or replacements should be made immediately. *Repair power tools and machinery only when the equipment is turned off.*

Hand Tools

Hand tools are the cause of many accidents and injuries when improperly used and in unsafe condition. Therefore, use the right tool for the right job in the right way. Use protective safety equipment where there is a job hazard. Keep the work area clear of hazards, with plenty of working space for solid footing. Tools should be in good condition and used for the purpose for which they were intended.

Portable and Power Tools

All equipment should be grounded. Check wiring and equipment regularly for defects. Be very careful when using equipment in wet areas. Use protective safety equipment when operating grinders, buffers, or other tools when there is danger of flying material.

Welding

Use the proper protective equipment at all times. Check for fire hazards before cutting or welding in areas of inflammable or explosive mixtures. *Only authorized personnel should operate welding equipment. The Ministry of Labour requires* that a 2 3/4 lb fire extinguisher be available.

Ladders

Ladders should be inspected periodically and maintained in good order. *Use safety belts* when awkward positions are necessary for the work. *Do not use metal ladders for electrical work.*

Lifting

Always lift with the leg muscles instead of the back and be sure your footing is secure. Bend you knees and keep your back straigth. Don't turn or twist your body when lifting. Get help if the load is too heavy or awkward to handle. Use mechanical devices for lifting whenever possible.

Equipment Servicing

When servicing plant and equipment: -

1. Check the ventilation of any enclosed or underground areas when gasoline operated pumps are to be used. Do not enter any crawl space under flooring for any purpose until the area has been ventilated. A second man should be present.
2. Do not grease or oil or attempt to service any machinery while it is in operation. Pumps on automatic control must be locked out and key carried by the operator during servicing.
3. Do not make any adjustments to operating machinery while alone. If it is necessary to run the unit to adjust it, a second man must be present and be beside the stop and go switch.
4. Do not service pumps and shafts in the dry wells of pumping stations, and in plants where the pumps and shafts are less than three feet apart without shutting off all pumps and locking them out.
5. Do not Under any circumstances, attempt to grease service pump shafting while standing on beams, piping, loose planks, guard rails, or by leaning out, over or through guard rails. If a ladder must be used, then a second man must be present to hold the ladder steady and to provide any other assistance.

PRECAUTIONS FOR ELECTRICAL MAINTENANCE

1. Plan safety into each job. Do not work around electrical panels, disconnects or switches alone.
2. Each employee shall be qualified both in experience and general knowledge to perform the particular electrical work which he is assigned, if not, an outside contractor should be called in.

3. Study the job carefully to determine all of the hazards present and to see that all necessary safeguards and safety devices are provided for safe working conditions.

4. Examine all safety devices before they are used to ensure that they are in good condition.

5. In all cases where work is being performed on or close to live conductors or equipment, at least two men shall work together. When it is necessary for one to leave, the other workman shall not continue the work until the first man returns.

6. Consider the results of each action. There is no reason for you to take chances that will endanger yourself and others.

7. Satisfy yourself you are working under safe conditions. The care exercised by others can not be relied upon.

8. Wear close fitting clothing, keep sleeves rolled down, avoid wearing unnecessary articles while working on or close to live circuits or apparatus.

9. Use only approved types of rubber or leather gloves.

10. Protect yourself by placing an insulated medium between you and ground or grounded apparatus to keep any part of your body from providing a path for electrical current when working on conductors or apparatus that may be energized.

11. Use rubber mats when working on any electrical control panel or switch and disconnect boxes.

12. Open and close switches completely with a firm positive motion. Switches in a partly open postion may arc or cause a flash-over with damaging results to the switch and possible injuries to the operator.

13. Open switches fully before removing fuses. To remove a fuse from a circuit carrying a current without opening the switch is particularly hazardous. Use an approved low-voltage fuse puller to remove fuses on a circuit of less than 500 volts (where no switch is provided) whether a disconnect is provided or not. Remove fuses by breaking contact with the hot side of the circuit first. Use the reverse procedure when replacing fuses. Insert the fuse in the cold terminal first.

14. Do not stand directly in front of panel to remove fuses or shut off disconnects.

15. Shut off the power when examining or making repairs or alterations on light and power circuits. When this is impractical Head Office must be contacted for further instructions before proceeding with the work.

16. Consider all electrical circuits to be dangerous. Treat dead circuits as though they were alive. This may prevent an accident as the circuit may be closed through an error of some other person.

17. Exercise extreme care when required to locate troubles on a series lamp circuit, before repairs are made make sure the power is cut off.

18. Lock or block open the control devices, open disconnect switches or remove fuses before examining, repairing or working on power circuits. After these precautions have been taken, attach tie-up tags worded "WORKMEN ARE WORKING ON LINE." The tag shall bear the name of the workman. Tie-up tags shall remain on the opened devices until removed by the workman whose name appears on the tag. If the workman leaves without removing his tag, it may be removed only on authorization of Head Office.

19. Before working on line circuits at a point remote from the control switch, which has been tagged, it is recommended that the conductors be grounded at a point on the line between the switch and the work station.

20. Make a complete check of the circuit before applying power for the first time. This is to be done by a qualified man in charge of the repairs, all other workmen to stand off at a safe distance.

FIRE PROTECTION

Each operator should have first hand knowledge of fire extinguisher, its ABC rating point of contact and time of operation.

A CO_2 fire extinguisher can only be used in an open area where the chance of using up the local oxygen is minimal. Never grab the horn of the extinguisher to direct the CO_2. The gas being expelled will freeze your hand to the horn causing serious injury. There is a handle provided. Do not direct the CO_2 at anyone. To fight the fire you must approach the fire from upwind, pull the pin and aim directly on the burning area.

The approximate operating time for CO_2 fire extinguishers is as follows:

2½ lb. 10 sec. ± 2 sec. 2. BC.
5 lb. 14 sec. ± 2 sec. 4. BC.
10 lb. 14 sec. ± 3 sec. 6. BC.
15 lb. 25 sec. ± 4 sec. 8. BC.
20 lb. 30 sec. ± 4 sec. 8. BC.

Note: The 2. BC etc., refers to the type of fires and area the extinguisher covers. (BC) indicates electrical, gas, oil type fires, "A" type are wood, paper, etc., CO_2 will not be effective on "A" type fires.

(2) indicates the extinguisher will put out a fire of not more than 2 square feet in area.

Weight indicated refers to contents only.

A Dry Chemical extinguisher can be used in any area. Approach from upwind and pull the pin, you do not have to stand as close to the fire as with CO_2. Dry Chemical will put a blanket of chemical over the fire, smothering it.

Note:

1. *All extinguishers must be refilled after using no matter what amount has been used.*
2. *All extinguishers must be hydrostatically tested every five years.*

DIGESTER AREA SAFETY

General

The Installation Requirements for the production, storage, handling and utilization of Digester Gas, handling and utilization of Propane and Fuel Oil and utilization of Natural Gas in WPCPs, when enacted as a CGA Code will apply to the construction of new waste water treatment plants and additions to existing plants. They will also apply to the upgrading of existing WPCPs. Included are requirements for safety procedures in carrying out maintenance of digesters and digester equipment. See Appendix C

The MOE plants are also subject to the requirements established by the Ministry and published in the Ministry Safety Policy Manual. Appropriate extracts of the Ministry Safety Policy Manual are attached as Appendix D.

It cannot be over-emphasized that digester gas is potentially highly dangerous, with respect to fire and explosion. However, a healthy respect allied with common sense and compliance with safety regulations renders gas handling no more dangerous than any other plant operation. Care must be taken from the start of work that all sources of ignition are guarded against, e.g., sparks from tools, using or moving equipment, smoking, wearing shoes with metal clips on heels, and leather soled shoes that are

worn sufficiently to expose the shoe nails. Non-sparking tools should be used when possible.

Hazardous Areas

Hazardous areas are those locations where flammable vapors are gases or combustible atmospheres are likely to be present. Regulations require that they be designed and located so as to prevent all possible sources of ignition. They include digester control rooms and buildings containing:

1. Dehydration, scrubbing gas,metering and regulating equipment.
2. Gas sampling sinks
3. Gas supply water accumulators and driptraps
4. Gas pump units
5. Gas pressure recording meters.

Adequately vented boiler rooms are excluded.

All electrical apparatus and equipment installed in these locations must be of explosion proof design. Combustible gas detection equipment is required and must automatically activate emergency ventilation systems and trigger audible alarms and readily visible lights at a preset value, 20% of the LEL of combustible gas. Detectors must be tested using 2% natural gas and calibrated at least once each month.

Mechanical air circulation of outside air through the location must be continuous. The air changes must be numerous enough to dilute and expel leaking gas at below the LEL. In any case there must be at least 5 air changes per hour. Emergency mechanical forced ventilation must also be provided to permit at least 10 air changes per hour. A switch controlling the emergency ventilation system must be provided at a convenient location just outside the door to the rooms and buildings. "DANGER, NO SMOKING OR OPEN FLAME" signs must be posted at:

1. The Entrances to a digester control room and building

2. Entrance to a gas compressor room
3. Ladders and stairways leading to a digester roof
4. The pressure/vacuum relief valve(s) on a digester roof.

ENTRY INTO CONFINED SPACES

By regulation, the digester is defined as a confined space. When entry into the digester is required observe the following basic rules: -

1. Provide adequate ventilation to remove gases and to supply oxygen. Be sure exhaust fan is on.
2. Never enter the digester alone. Always have someone to help in the event of trouble.
3. Use safety harness equipped with safety line.
4. Check for gases with a combustible gas analyzer. The type of tests made, the testing unit used and by whom MUST be recorded in the confined space Entry Permit.
5. Be extremely careful about footing.
6. Use bucket and rope to lower tools and equipment.
7. A man hoist for ease of entry.

Included in Appendix C, Extracts from Ministry Safety Policy, are detailed guidelines for entry into confined spaces.

SAFETY IN REPAIR OPERATIONS - Digester Roof Equipment

When repairing equipment on the digester roof the following procedure is to be followed:

1. A few days prior to the start of the work, release the gas under the roof and lower the sludge level to at least three feet below the lip of the draft-tube of the mixer (if there is one).
2. Brief all personnel involved in this work of the hazards, the safety equipment required and the precautions to be taken.
3. Have at the plant site all equipment required for the work

4. All electrical controls to the equipment to be removed or serviced, must be disconnected, tagged and locked out, the key being kept by the Chief Operator.

5. During the actual disconnection and removal of the equipment from the roof, explosion meter tests must be recorded at the open manholes.

6. When replacing and connecting the equipment on the roof, explosion meter readings are to be recorded.

7. The use of a hoisting crane and operator to remove and replace equipment on the roof of the digester is covered by section 21-2 of the Industrial Safety Act.

Mechanical Mixer

To provide an adequate safety factor and reduce the digester gas being produced to below the lower explosive limits (LEL) the following procedure must be followed.

1. Stop all raw sludge pumping to the digester two days before work is started.

2. a. Stop the operation of the mixing units one day before work is started.

   b. Isolate the digester from all sources of gas.

   c. Release the stored gas under the roof slowly to atmosphere through the roof P.R.V., leave valve open.

3. Open all manhole covers located on the roof.

   When the manhole covers are opened the digester gas still contained under the roof will vent to atmosphere through the open manholes. The gas will be seen as a vapour which is highly explosive. The length of time it takes to dissipate depends on the digester size.

All personnel must leave the roof area until this vapour has dissipated, except the individual(s) operating the gas analyzer.
An extraction fan 18" in diameter having a Group 1, Class D, explosion proof motor and a CFM OF 5500 output must be mounted on one of the open manholes.
A further reading of the discharge of the fan must be taken. A reading of .2% would indicate safe working conditions on the digester roof.

4. When the mixer unit is being lifted off its base a hose from a cylinder of nitrogen or carbon dioxide must be inserted into the opening as soon as there is a sufficient room and the area around the mixer unit diluted with the inert gas.

   The nitrogen or CO_2 gas discharge is controlled by a regulator on the gas cylinder.

   While the mixing unit or units are being repaired a one inch hole could be drilled through the unit top plate and a short nipple be installed with a threaded cap. The nipple could be used to attach an inert gas pipe or hose when it is necessary to remove the mixing unit in the future.

5. a. During the period when the mixing units are being repaired, the manhole covers should be closed down on a piece of 2 X 4 lying across the opening leaving an air passage into the digester.

   b. A tarpaulin or piece of plywood placed over the opening and held down is necessary.

   c. The extraction fan left in place and in continuous operation.

6. When the mixing units are being replaced the manhole covers would be re-opened fully and a gas reading made at intervals on the discharge of the extraction fan.

NOTE: The type of tests made, the testing unit used and by whom must be recorded in the confined space entry permit.

Waste Gas Burners

When it is necessary to light a waste gas burner by hand, certain precautions must be taken to avoid being burned when the gas is ignited. The suggested procedure is as follows:-

1. Always use an oily rag wrapped around a strong stick at least eight feet long. Do not use a hand torch or match.
2. Stand back about 10 feet from the burner, light the rag and approach the burner from a cross-wind direction, not up-wind or down-wind.
3. Thrust the burning rag on the stick at arms length into the ignition hole, or if the wind direction will not permit this, place the rag at the bottom or top of the burner pot.

The reason for not igniting the burner from down-wind is obvious, but standing up-wind, you could find yourself in a back draft or down draft. You might then be enveloped by swirling burning gas. The use of natural gas or propane gas pilot ignition removes the necessity of hand lighting and assures that all waste gases are burned at all times.

PERSONAL HYGIENE

For the sake of your health and the health of your family:

1. Never eat your lunch or put anything into your mouth without first washing your hands.
2. Do not smoke while working in tanks, on pumps, trucks, filters, etc. Remember, you inhale or ingest the filth that collects on the cigarette from dirty hands. Save your smoking time for lunch hours or at home.
3. Never put your hands above your collar when working on any plant equipment, if possible.
4. Don't wear your overalls or rubber boots to the dining area.
5. Always wear your rubber boots when working in tanks, around sludge, washing down, etc. Don't wear your street shoes.
6. Keep your street shoes in your locker. Remember: what your shoes pick up at the plant they will leave on the floor of your home.
7. Don't wear your coveralls or rubber boots in your car or home.
8. Have a complete change of clothing to wear when going home.
9. Always clean any equipment such as safety belts, harness, face masks, gloves, etc., after using. You or someone else may want to use it again.
10. Always wear rubber or plastic coated gloves when cleaning out pumps, handling hoses, or when working around the plant.
11. Avoid putting on gloves when your hands are dirty. Wash first.

12. Wash with plenty of water or take a shower immediately after being splashed with sludge, or any chemical. *DON'T DELAY.*

13. Don't just wash your hands before going home. Wash your face thoroughly too. There is more of your face to carry germs than there is of your hands.

14. Wear a hat when working around sludge tanks, filters, or cleaning out grit or other channels. Don't go home with your head resembling a mop that just wiped up the floor around a cleaned out pump.

15. Keep your fingernails cut short and clean - they are excellent carrying places for dirt and germs.

FIRST AID

1. Remove patient from gas area. Patient should be kept in a warm room (about 21°C). Supply blankets under and over patient. Keep patient warm and quiet. Rest is essential.

2. Place patient on back. Place a folded coat, blanket, etc., under victim's shoulders so his head falls well back. This maintains a clear air passage to lungs of victim.

3. Call for medical aid immediately.

4. Promptly remove clothing contaminated with liquid chlorine, or chlorinated water. Keep patient warm with blankets.

5. A mixture of carbon dioxide and oxygen, with no more than 7% carbon dioxide, may be given. This mixture, already prepared and sold with the necessary apparatus, can be administered for periods of two minutes followed by two-minute rest periods for no longer than thirty minutes. Follow instructions of the gas apparatus supplier carefully. If carbon dioxide and oxygen mixture is not readily available, then oxygen alone may be used, or fresh air "Air Pack".

6. Milk may be given in mild cases as a relief from throat irritation.

7. If breathing seems to have stopped, immediately start "Mouth to Mouth" or "Revised Sylvester" methods of artificial respiration. *Do not exceed 17 to 18 movements per minute.* If possible, assist respiration with an inhalator or respirator. See page 6-23.

8. When eyes are irritated with chlorine, wash repeatedly with water and then with 1% boracic acid solution. Castor or olive oil drops may be used. In severe cases of eye contamination due

to chlorine, use bubbler fountain, hose, or eye cup. Irrigate for 15 minutes. A routine of 5 minutes irrigation and 10 minutes rest should then be followed for one hour. Prompt action is absolutely essential to protect eyesight.

9. Areas of the skin which have been splashed with liquid chlorine or chlorinated water should be repeatedly washed with water. After thorough washing, any burned area should be covered with a sterile dressing and bandaged snugly unless blisters are apparent; then bandage loosely.

If facilities are available, it is generally recommended that patients be removed to hospital as soon as possible, unless recovery from chlorine exposure is prompt and the exposure mild.

REVISED SYLVESTER METHOD OF ARTIFICIAL RESPIRATION

Lose no time in starting - delay can be fatal.

1. Clear mouth of any obstructions.
2. Lay casualty on his back.
3. Elevate shoulders of casualty with a folded coat, blanket, etc., so his head falls well back. This maintains a clear air passage to his lungs.
4. Place casualty.'s head between your knees and grasp his arms at the wrist.
5. Cross arms over the lower half of the breastbone and rocking forward, press firmly downwards (about 20 lbs. pressure), forcing air out of lungs of casualty.
6. Release the pressure by rocking back and pull his arms upwards, outwards and backwards. This extends the chest walls and draws air into the casualty's lungs.

7. Repeat cycle 12 to 15 times per minute until doctor arrives and says to stop, or until normal breathing is restored, or rigor mortis has set in.

ORAL RESUSCITATION

Lose no time in starting - delay can be fatal.

1. Clear mouth of any obstructions.
2. Lay casualty on his back.
3. Place a folded coat, blanket, etc., under victim's shoulders so his head falls well back. This maintains a clear air passage to his lungs.
4. Kneel beside casualty's head.
5. Pinch his nose and open your mouth wide and blow into his mouth strongly enough to cause the casualty's chest to rise.
6. Remove your mouth. Casualty's chest should fall.
7. Repeat cycle 12 to 15 times per minute until doctor arrives and says to stop, or normal breathing is restored, or rigor mortis has set in.

Artificial respiration must be continued until natural breathing is restored, a doctor says to stop, or rigor mortis sets in.

EXTRACTS

APPENDIX C

DRAFT CODE CGA B105

INSTALLATION CODE

FOR

DIGESTER GAS SYSTEMS

1. SCOPE

1.1 This Code applies to the installation of systems for the production, handling, storage and utilization of digester gas in wastewater treatment plants.

1.2 This Code applies to wastewater treatment plants and new additions to existing plants.

1.3 Within the scope of clauses 1.1 and 1.2, there may be provisions not covered by this Code, in which case the applicable provisions of the enforcing authorities shall apply.

2. GENERAL REQUIREMENTS

2.1 Appliances, accessories, components, equipment and materials shall be of a type and rating approved for the specific purpose for which they are employed and acceptable to the enforcing authorities.

2.2 All work on appliances or equipment utilizing or handling digester gas shall be performed by qualified personel licenced as required by the enforcing authority.

2.3 The use of appliances, accessories, components, equipment and materials shall be prohibited where such items have deteriorated to the extent that a hazardous condition is created.

2.4 Appliances, accessories, components, equipment and materials shall be installed in accordance with the applicable requirements of Standards CGA B105, CGA B149.1, CGA B149.2, CSA B139, the Canadian

Electrical Code and be acceptable to the enforcing authorities.

2.5 The handling, storage and utilization of propane shall conform to the current code CGA B149.2 INSTALLATION CODE FOR PROPANE BURNING APPLIANCES AND EQUIPMENT and the provisions of the enforcing authorities.

2.6 The handling, storage, and utilization of fuel oil shall conform to the current code CSA B139 INSTALLATION CODE FOR OIL BURNING EQUIPMENT and the provisions of the enforcing authorities.

2.7 The utilization of natural gas shall conform to the current code CGA B149.1 INSTALLATION CODE FOR NATURAL GAS BURNING APPLIANCES AND EQUIPMENT and the provisions of the enforcing authorities.

2.8 The use of any open flame, spark producing tools or any other source of ignition on or adjacent to any working digester or in a hazardous area is prohibited except by special permission in writing from the enforcing authority. Note - this is a listed Prohibited Practice.

2.9 Clause 2.8 shall also apply to all digesters and sludge holding tanks not in use containing any amount of sludge of any age. Note - This is a listed Prohibited Practice.

3 PROHIBITED PRACTICES

3.1 Refer to the following clauses for the prohibited practices.

2.8 General Requirements

2.9 General Requirements

4.5.3 Pressure/Vacuum Relief and Flame Arresting

5.2.4 Cast Iron Fittings

5.3.5.2 Carbon Steel Pipe Underground

5.3.5.4 Screwed joints on pipe over 2½" (65mm)

5.3.6.3 Solder joints and connections

5.8.11 Threaded fittings underground

11.2 Water accumulators with drip traps

15.1.1 Exhausting Unburned Digester Gas

4. DIGESTERS

4.1 Digester Roofs

4.1.1 Leakage Tests

A steel digester roof of any size or type after surface preparation but before final painting or coating and being put into service shall be subjected to the tests specified in sections 4.1.4 and 4.1.5 and shall show no evidence of leaking or structural deformation during tests.

4.1.2 A digester roof of material other than steel of any size or type after surface preparation but before final painting or coating and being put into service shall be subjected to the tests specified in sections 4.1.5 and shall show no evidence of leaking or structural deformation during tests.

4.1.3 The vacuum and pressure tests specified in sections 4.1.4 and 4.1.5 shall be witnessed by and proven acceptable to the enforcing authority or to such representative as appointed by the enforcing authority and shall be accompanied by a written report.

4.1.4 Vacuum Test (Steel Roofs)

All joints, welds, connections, seals, etc., and any other area of possible gas leakage shall where practicable be tested to a partial vacuum of not less than 14 kPa negative pressure for a duration of not less than the time necessary for a complete examination of the area being tested, but in no case less than 60 s. (See Appendix for tests).

4.1.5 Pressure Tests

4.1.5.1 A newly constructed fixed type digester roof shall be tested, using air or inert gas, at an internal positive pressure of not less than 1 1/2 times the maximum operating pressure of the digester for a period of not less than:

a) 3 h for a steel roof.

b) 6 h for a concrete roof and the test is not to be conducted until after at least a 28 day curing period.

c) 6 h for a fibreglass roof.

4.1.5.2 A new floating gas holder type digester roof shall be tested using air or inert gas at an internal positive pressure of not less than 0.75 kPa in excess of the maximum operating pressure of the digester for a period of not less than 3 h for a steel roof and 6 h for a fibreglass roof and the pressure test shall be carried out as in the Appendix.

4.1.5.3 A new floating pontoon type digester roof shall be tested using air or inert gas at an internal pressure of not less than the maximum operating positive pressure of the digester for a period of not less than 3 h and the pressure test shall be carried out as in the Appendix.

4.1.6 Water Seal Skirt Depth

4.1.6.1 A fixed type digester roof which incorporates an inner perimeter skirt to provide a water type gas seal shall have a skirt depth of not less than 1.5 m measured vertically and be capable, when installed, of a water seal depth of not less than 760 mm measured vertically.

4.1.6.2 The floating digester roof (both floating pontoon and gas holder types) shall have a skirt depth sufficient to provide a submerged liquid seal depth of at least 450 mm under all operating conditions.

4.1.7 Manholes

4.1.7.1 In the roof of each digester with an internal diameter larger than 15 m, there shall be not less than three manholes of which at least one shall be not less than 1.1 m internal diameter or sufficient area to allow a man equiped with an air pack easy access into the digester via a portable ladder.

4.1.7.2 In the roof of each digester with an internal diameter of 15 m or less there shall be not less than two manholes of which at least one shall be not less than 1.1 m internal diameter or sufficient area to allow a man equiped with an air pack easy access into the digester via a portable ladder.

4.2 Testing after Cleanout

4.2.1 Working digesters having been emptied for cleanout or repair, shall be subjected to the same leak test procedures as described under clause 4.1.5 before returning to service. The tests shall be witnessed by and proven acceptable to the enforcing authority

or to such representative as appointed by the enforcing authority and shall be accompanied by a written report.

4.3 Gas Draw Off

4.3.1 The point of digester gas draw off from the gas holding space of the digester shall be from the gas dome.

4.3.2 The digester gas draw off piping shall be corrosion resistant, located external from the digester and accessible for repair without the necessity of entering the digester tank.

4.4 Liquid Overflow

The internal cross-sectional area of the liquid overflow line shall be at least equal to that of the sludge supply pipe to the digester but in no case shall it be less than the cross-sectional area of a nominal 6 inch (152.4 mm) diameter Schedule 40 pipe.

16. HAZARDOUS AREAS

16.1 Digester control room(s) and building(s) containing dehydration, scrubbing, gas metering and regulating equipment, digester sludge sampling sinks, gas supply water accumulators and drip traps, non-hermetically sealed gas compressor units and gas pressure recording meters shall be designated as locations where flamable gases, flamable vapours or combustible atmospheres are likely to be present and shall be designed and located so as to eliminate all possible sources of ignition.

16.1.1 Where an isolating facility is provided that is designed and constructed for specific accessories and equipment as designated in 16.1 so that hazardous gases are exhausted to outdoors and means of detection with enuciating audible and visible alarms are provided at the facility to warn of unacceptable accumulation, the requirements for hazardous areas as in 16.1 will not apply if the facility provided is acceptable to the enforcing authority.

16.1.2 Floor drains in hazardous areas shall be provided with water traps complete with a trap seal priming system to act as gas seals preventing hazardous gases for communicating with non hazardous areas.

16.1.3 In the locations described in clause 16.1, mechanical air circulation of outside air through the location to outdoors shall be provided continuously and the air changes thereby provided shall be numerous enough to provide a reasonably pure ambient atmosphere, to allow for safe entry and in no case be less than 5 air changes per hour.

16.1.4 In the locations described in clause 16.1 supplementary mechanical forced ventilation shall provide at least 10 air changes an hour and a manual switch for the supplementary ventilation shall be placed in a convenient readily accessible location just outside the door to the digester control room(s)

16.1.5 All electrical apparatus and equipment installed in the locations described in clause 16.1 shall be acceptable for use in Class 1 Group D, Division 2 Hazardous Locations as outlined in the current code CSA C22.1 CANADIAN ELECTRICAL CODE.

17. COMBUSTIBLE GAS DETECTION EQUIPMENT

17.1 Combustible gas detection equipment conforming to the current standard CSA C22.2 #152 COMBUSTIBLE GAS DETECTION INSTRUMENTS shall be installed with an adequate number of strategically located sensing stations in all locations described in clause 16.1.1 and any other area/location not described but so designated by the enforcing authority.

17.2 The placement of each sensing head shall be determined by on site ventilation tests before sensor installation to assure the best location for the designed function.

17.3 Combustible gas detectors shall be interlocked to automatically activate emergency ventilation systems and trigger the enunciation of audible alarms and readily visible lights at a presen value level of combustible gas indication well below the L.E.L. (Lower explosive limit) value but in no case more than 20% of the L.E.L. and the alarms and lights shall be located so as to be readily heard and seen by responsible plant personnel.

17.4 Combustible gas detection signals and systems shall be provided with an auxilliary power supply to ensure continuous operation during any failure of normal power supply.

18 BLEEDS AND VENTS

18.1 Valves, regulators, manometers and other control devices that require venting shall either be vented separately or shall be manifolded in accordance with either clause 18.2 or 18.3, whichever is applicable.

18.2 Relief vents from relief valves shall be vented separately and shall not be manifolded with bleed vents from other devices, and the internal area of a relief vent shall not be less than that of the relief vent opening.

18.3 A common manifold for the bleed vents of regulators and other control devices (excluding relief valves) shall have an area not less than twice the total area of the connected bleed vents and the internal area of pipe used for a single bleed or vent line shall not be less than 67 square mm. (Where copper tubing is used see Section 5.2.1.)

18.4 Bleeds and vents from control components in an indoor enclosed control cabinet, that requires venting shall be vented to the outdoors in accordance with section 18.6.

18.5 Bleed and vent lines in a control cabinet on outdoor units shall comply with the applicable requirements of 18.1 to 18.3 inclusive.

18.6 Bleed and vent lines when piped to a roof shall terminate not less than 600 mm above the roof and be fitted with a 180° bend and bug screen.

18.7 All relief, bleed and vent lines shall terminate in a safe location. (See also section 15).

19 SAFETY ELECTRICAL CIRCUITS

19.1 The electrical power for the safety control circuit shall be single phase with one side grounded. Where a step down or isolation transformer is used one of the conductors from the secondary winding shall be grounded.

All safety circuit breaking contacts shall be in the ungrounded line. For protection, the maximum nominal voltage shall not exceed 120 V and the ungrounded side of the line shall be protected against circuit overload.

19.2 The power supply to a control circuit shall not be interrupted by a limit control or operating control other than a manually operated switch, when it is necessary to have uninterrupted power to maintain that control circuit in an operative state.

21 ENGINES

21.1 Engines designed to utilize digester gas shall be approved for the application and/or acceptable to the enforcing authority.

21.2 Engines shall be located in a non hazardous area.

21.3 Engines shall be installed in accordance with the B149 Codes and for acceptable valving arrangement see Part II schematic diagram Figure 38 series.

22 INCINERATORS

22.1 Incinerators utilizing digester gas shall be approved and/or accepted by the enforcing authority.

22.2 Location-Incinerators shall be located in a non hazardous area and installed in accordance with the requirements of the enforcing authority.

22.3 Incinerator Vent Stack Terminations shall not be less than 15 m from the nearest source of ignition or combustible gas.

22.4 Ventilation-shall be in accordance with the requirements of the B149 Codes.

22.5 Valving Arrangements are shown in the schematic drawing in the Appendix.

APPENDIX A

VACUUM TEST METHODS (ref. clause 4.1.4)

a) Vacuum testing is conveniently performed by means of a metal testing box 150 mm wide by 760 mm long, with a glass window in the top. The open bottom is sealed against the roof surface by a sponge-rubber gasket. Suitable connections, valves, and gauges should be provided to effectively carry out the tests.

b) Approximately 760 mm of the seam under test is brushed with a soap suds solution or linseed oil, (in freezing weather, a non freezing solution may be necessary for outdoor testing) the vacuum box is then placed over the coated section of the seam and vacuum is applied to the box. The presence of porosity, and cracks in welded seams, leaking joints, leaking connections, etc., is indicated by bubbles or foam produced by air sucked through the welded seam or other type of joint, connection, etc.

c) A partial vacuum can be drawn on the box by any convenient method, such as connection to a gasoline or diesel motor intake manifold or to an air ejector or vacuum pump.

PRESSURE TESTS (ref. clauses 4.1.4.2 & 4.1.4.3

The pressure tests as in clauses 4.1.4.2 and 4.1.4.3 shall be carried out by filling the digester tank with liquid to such a level that the entrapped air lifts the roof free of the corbels and additional pressure as required shall be provided by introduction of air or inert gas by other means.

Additional pressure as required shall be provided by the introduction of air or inert gas to raise the roof to the upper stops to verify the structural integrity of the entire digester tank.

EXTRACTS

FROM

MINISTRY SAFETY POLICY

Part IV	CONFINED SPACES
VI	ELECTRICAL
VII VIII	ITEM 5 VENTILATION
IX	FLAMMABLE LIQUID AND GASES - FIRE PROTECTION

Part. IV

ITEM NUMBERS	SUB. ITEM NUMBERS	CONFINED SPACES	I.S.A. NUMBERS
1		DEFINITION OF A CONFINED SPACE	Sec. 84-88
	i.	An area of any depth.	
	ii.	Of any size or configuration.	
	iii.	Above or below ground.	
	iv.	Not provided with any means of ventilation.	
	v.	Having no means of easy egress.	
	vi.	And/or where, because of its contents or by infiltration an accumulation of hazardous gases and/or oxygen deficient atmosphere may exist or develop.	
2		COMPETENT PERSON A person with experience, training, knowledge and has proven by written examination that he has a complete understanding of the safety requirements of Part 5.	
3		SAFETY EQUIPMENT REQUIRED Oxygen meter 0-25% range. Combustible gas analyzer 0-100 L.E.L. Range. Portable venting unit of approved capacity and design. Parachute type safety harness.(2) Safety ropes or manhoist. Self contained breathing equipment. Colourmetric meter.	
4		POSTING OF WARNING SIGNS See Part 6, Item 4.	
5		VENTILATION See Part 8, Item 4(a)	
6		ENTERING CONFINED SPACE	
	a.	No person shall enter a confined space until the tester has confirmed the space safe for entry.	

ITEM NUMBERS	SUB. ITEM NUMBERS	CONFINED SPACES	L.S.A. NUMBERS
6	b	When the person or persons in the confined space are likely to stay longer in the confined space than is normally required for an inspection, a portable ventilation unit must be utilized. The ventilation unit shall be in continuous operation as long as the space is occupied.	
	c	All persons while working in a confined space shall wear a parachute type safety harness.	
	d	At least two persons shall be at the entrance manhole to handle the safety rope or one person and a manhoist and safety cable.	
	e	No confined space shall be entered by a person while alone.	
	f	A confined space where the tester records more than 0% of the L.E.L. of explosive gases or the concentration of oxygen is less than 18% or more than 23%, more than 0% H2S, or when the conditions in the confined space changes from a negative reading of the L.E.L. or below 18% or above 23% of oxygen the persons entering the space shall, wear suitable self contained breathing equipment, parachute type safety harness. NOTE: All equipment to be calibrated by qualified personnel.	
	g	Entrance to a confined space under the above conditions shall be only for emergency reasons and the persons must leave the space as soon as possible.	
7		Wet Wells of Sewage Pumping Stations regardless of configuration are confined spaces. The requirements of Sections 84 to 87 apply mutatis mutandis to any confined space while any person remains in that space.	Sec. 88
		NOTE: SAFETY EMERGENCY PROCEDURES Directives will be issued outlining procedures to be followed in times of emergency.	

ITEM NUMBERS	SUB. ITEM NUMBERS	CONFINED SPACES DIGESTER CLEANOUT	I.S.A. NUMBERS
1		COMPETENT PERSON	
		A person with experience, training, knowledge and has proven by written examination that he has a complete understanding of the safety requirements of Part 5A.	
2		SAFETY EQUIPMENT REQUIRED	
		Oxygen meter 0-25% range. Combustible gas analyzer 0-1.0 L.E.L. range. Portable ventilation providing 30 air changes per hour having a class "I" group "D" explosion proof meter. Parachute type safety harness, one for each person entering the tank. 40-foot aluminum extension ladder. Self contained breathing equipment. Portable flood lights. Overalls, rubber boots (hip size) hard hats rubber or plastic coated cotton gloves.	
3		POSTING OF WARNING SIGNS	
		No smoking, etc.	
4		VENTILATION	
	a-	The ventilation fan shall be located on one of the roof manholes and positioned so that the fan is exhausting the air and any gases in the digester to atmosphere.	
	b-	The ventilation fan shall be in continuous operation twenty four hours per day from the first entrance of persons until the cleanout is completed.	
	c-	The opening of the bulkhead door as soon as possible is required to allow outside air to circulate through the digester from bottom up through the roof.	
5		DIGESTER PROCEDURE	
	a-	No person shall enter the digester until the competent person has confirmed that the digester is safe for entry.	
	b-	No person shall enter a digester while alone and without safety equipment.	

ITEM NUMBERS	SUB. ITEM NUMBERS	CONFINED SPACES DIGESTER CLEANOUT	I.S.A. NUMBERS
5		DIGESTER PROCEDURE	
	c-	All persons working in a digester will wear the protective clothing and equipment provided.	
	d-	At least (2) two persons are required in the vicinity of the entrance manhole on the roof to assist in the removal of a person overcome or injured while in the digester.	
	e-	The bulkhead door should be used as soon as possible for safer entrance and egress.	

ITEM NUMBERS	SUB.ITEM NUMBERS	ELECTRICAL	I.S.A. NUMBERS
1		COMPETENT PERSON A person with experience, training, knowledge and has proven by written examination that he has a complete understanding of the safety requirements of Part.7.	
2		APPROVED SAFETY EQUIPMENT REQUIRED Rubber gloves, heavy duty leather gloves, rubber mats, ground wire and clips, fuse pullers voltage testing device, face shields.	Secs.41-45
3		Electrical equipment and wiring shall be approved for the intended use by The Canadian Standards Association (CSA) or the Ontario Hydro Inspection Department.	
4		The entrance to a room or guarded location containing exposed live electrical parts shall be marked with conspicuous warning signs forbidding entry to unauthorized persons.	
5		Warning signs shall be posted on Hydro poles carrying high voltage on M.O.E. Property warning persons of the wires and their voltage.	
6		When it is necessary to work on any structure within fifty feet of any overhead power line regardless of the voltage the following procedure shall be followed:	
	a-	The person doing the work shall be informed of the presence of the wire.	
	b-	If a ladder is required to do the work it shall be constructed of fibreglass.	
	c-	Whenever possible the power line should be disconnected until the work is completed.	—
	d-	When the power line cannot be disconnected a second person is required to keep the person doing the work under observation and any assistance that may be required of him.	
	e-	Be trained in A.R. and C.P.R.	

Part.VI

ITEM NUMBERS	SUB. ITEM NUMBERS		I.S.A. NUMBERS
7		MAINTENANCE	See.43.1&2.
	1	Subject to subsection.2. the power supply to live electrical installation or equipment shall be isolated, tested, locked out (with personnel lock) and tagged with identity of personnel involved and reason for lock out prior to any work being done on the installations or equipment.	
	2	Where it is not practicable to disconnect the power supply to live electrical installations. a- Approved rubber gloves, mats, shields or other protective equipment adequate to ensure the safety of all persons shall be used while work is being performed. b- A person other than the person doing the work who is trained in the use of artificial respiration shall be conventiently available while the work is being performed.	
8		ELECTRICAL EQUIPMENT AND TOOLS Cord connected electrical equipment and tools shall be effectively grounded.	
9		Tools and other equipment which are capable of conducting electricity and endangering the safety of any person, shall not be used in such proximity to any live electrical installation or equipment that they might make contact with the live conductor.	
10		Tools and equipment must be of approved type and maintained in good condition.	

Part. VIA

1		The Ontario Hydro Electric Code must be followed at all times.	
2		Only competent personnel shall work on electrical equipment.	

ITEM NUMBERS	SUB.ITEM NUMBERS		I.S.A. NUMBERS
5		VENTILATION	Sec.27 a & b

An industrial establishment shall be adequately ventilated by either natural or mechanical means so as to ensure the safety of all persons.

Where the air may be contaminated in an industrial establishment the contamination shall, so far as practicable be removed at or near the source of contamination.

The minimum requirements of natural draft air changes in rooms or areas where toxic explosive or choking dusts or gases may accumulate and in boiler rooms is three air changes per hour.

The minimum requirements for mechanical ventilation air changes in rooms or areas containing chlorine cylinders and equipment the mechanical ventilation requirements are thirty air changes per hour.(See chlorine standards and specifications No. 10).

In all other rooms requiring mechanical ventilation the minimum air changes per hour is five.

In areas that explosive gases may accumulate the electrical components of the mechanical ventilation system shall be of Class 1 Group D construction.

The exhaust from the ventilation system shall be so arranged that the exhausted contaminents cannot enter any other work area or re-enter the area from which they were exhausted.

FLAMMABLE LIQUIDS & GASES - FIRE PROTECTION

ITEM NUMBERS	SUB. ITEM NUMBERS	COMPETENT PERSON	I.S.A. NUMBERS
1		A person with experience, training, knowledge and has proven by written examination that he has a complete understanding of the safety requirements of Part 9 and has a gas maintenance fitter's certificate.	
2		SAFETY EQUIPMENT REQUIRED Oxygen meter 0 - 25 range. Combustible gas analyzer 0 - 1.0 L.E.L. Range. Self contained breathing equipment.	
3		POSTING OF WARNING SIGNS Signs warning persons of outside storage tanks containing flammable liquids or gases above, or below ground and indicating "no-smoking" restrictions. Signs warning persons of "no-smoking or open lights" areas i.e. Digesters, digester control buildings, gas compressor rooms etc.	
4		VENTILATION	Sec. 30,31
	a	In rooms where gasoline and associated products are stored in five gallon or smaller cans the natural ventilation of the room shall not be less than three air changes per hour.	
	b	Venting of above or below ground storage tanks shall be in accordance to the Gasoline Handling Code 1974, Section 13-16, and Sections 11-14 (Ontario Regulations 380, 1974).	
	c	Ventilation of digester control buildings, boiler rooms and gas compressor rooms shall comply with The Safety Requirements S.R. 105, Ministry of Consumer and Commercial Relations.	
5		Storage of gasoline in bulk quantities outside and above ground shall be in a container approved for the application, See (Gasoline	

ITEM NUMBERS	SUB.ITEM NUMBERS	
		Handling Code 1974, Section 6) located on a concrete or wooden base ten feet from the nearest building and be provided with a no-smoking sign as described by the the Gasoline Handling Code 1974, Section 6.
6	a	Storage of gasoline in one or five gallon containers shall be in an area that has no potential source of ignition in a clear open space described in Item 4 under Ventilation.
	b	The containers shall be of metal equipped with spring loaded safety caps and approved for the application as described in the Gasoline Handling Act (Ontario Regulation 380, 1974) Section 1, Sub-section (iv), Page 11.
7		FUEL OIL STORAGE
		Storage fuel oil tanks underground See Ontario Fuel Oil Equipment Installation Regulation 298/72, Sections 6.3 - 6.3.12.
		Enclosed fuel oil supply tanks indoors. See Section 6.5 - 6.5.7
		Non-enclosed supply tanks, safety cans, auxiliary tanks, Sections 6.4 - 6.4.7.
8		FUEL OIL
		The storage, transmission and utilization of fuel oil from storage area to boiler burner shall be in accordance with the Ontario Fuel Oil Equipment Installation Regulation 1972 and the Safety Requirements (S.R. 105) 1977. Energy Branch, Ministry of Consumer and Commercial Relations.
9		FLAMMABLE GASES
		Digester Gas (CH_4)
		The storage area (Digester Roof, Gas Sphere) transmission pipe systems, including all control and safety units and the utilization of this gas shall be in accordance to the Safety Requirements (S.R. 105), 1977, Energy Safety Branch, Ministry of Consumer and Commercial Relations

ITEM NUMBERS	SUB. ITEM NUMBERS		I.S.A. NUMBERS
10		NATURAL GAS (CH_4)	
		The utilization of natural gas as a fuel and the transmission pipe system controls and safety units down stream from the gas meter shall be in accordance to the Safety Requirements (S.R. 105) 1977, Ministry of Consumers and Commercial Relations.	
11		PROPANE GAS	
		The utilization of propane gas for pilots and laboratory work and the transmisssion piping shall be in accordance to the Safety Requirements (S.R. 105) 1977, and the Propane Handling Act 1972, Energy Branch, Ministry of Consumer and Commercial Relations.	
		NOTE:	
		The storage area for propane cylinders shall be outside, standing on a concrete or wooden base, chained individually to a wall or steel post and be easily accessible to the delivery truck but not adjacent to a road or passage way frequently used by persons and for motor traffic.	
12		FIRE PROTECTION, FIRE EXTINGUISHERS	Sec.29(a,b,c)
		The number, size and type of fire extinguisher required in plant buildings is dependent on the protection desired.	
		The minimum size extinguisher should not be below five (5 lbs) and this size should only be used for trucks, as part of a maintenance kit. Permanently installed extinguisher either dry chemical or carbon dioxide (CO_2) should not be less than ten (10 lbs) size (contents only) due to limited area they are effective and the short time they are active, i.e. a ten lb. extinguisher is rated at 6 B.C. time .14 Sec. X 2 Sec. for a CO_2. The dry chemical type rated at 10 B.C., 14 Seconds X 2 Seconds operating time. A 2 3/4 lb. dry chemical extinguisher is required for all welding equipments.	
		All weights quoted are net weights.	